Prevalence of, and Risk Factors for, Presenting Visual Impairment: Findings from a vision screening programme based on UK NSC guidance in a multi-ethnic population.

Running Title: Visual Acuity in Bradford children aged 4-5 years

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Competing interests: None declared

Grants: AB is funded by a National Institute for Health Research Post-Doctoral Fellowship Award (PDF-2013-06-050). The Born in Bradford study presents independent research commissioned by the National Institute for Health Research Collaboration for Applied Health Research and Care (NIHR CLAHRC) and the Programme Grants for Applied Research funding scheme (RP-PG-0407-10044). The views expressed are those of the author(s) and not necessarily those of the NHS, the NIHR or the Department of Health.

Word Count: 3498

ABSTRACT

Purpose:

To determine presenting visual acuity levels and explore the factors associated with failing vision screening in a multi-ethnic population of UK children aged 4-5 years.

Methods:

Visual acuity (VA) using the logMAR Crowded Test was measured in 16541 children in a population-based vision screening programme. Referral for cycloplegic examination was based on national recommendations (>0.20logMAR in one or both eyes). Presenting visual impairment (PVI) was defined as VA >0.3logMAR in the better eye. Multivariable logistic regression was used to assess the association of ethnicity, maternal and early-life factors with failing vision screening and PVI in participants of the Born in Bradford birth cohort.

Results:

2467/16541 (15%) failed vision screening, 732 (4.4%) had PVI. Children of Pakistani (OR 2.49; 95% CI: 1.74 to 3.60) and other ethnicities (OR 2.00; 95% CI: 1.28 to 3.12) showed increased odds of PVI compared to white children. Children born to older mothers (OR 1.63; 95% CI: 1.19 to 2.24) and of low birth weight (OR 1.52; 95% CI: 1.00 to 2.34) also showed increased odds. Follow-up results were available for 1068 (43.3%) children, 993 (93%) were true positives; 932 (94%) of these had significant refractive error. Astigmatism (>1DC) (44%) was more common in children of Pakistani ethnicity and hypermetropia (>3.0DS) (27%) in white children (Fisher's exact $p<0.001$).

Conclusions:

A high prevalence of PVI is reported. Failing vision screening and PVI were highly associated with ethnicity. The positive predictive value of the vision screening programme was good, with only 7% of children followed up confirmed as false positives.

INTRODUCTION

The United Kingdom National Screening Committee (UK NSC) recommends vision screening for all children at age 4-5 years.[1] This is the first vision test for the majority of children in the UK and is the key assessment for identifying decreased visual acuity (VA). A reduction in VA is highly indicative of the presence of an associated condition such as refractive error, strabismus and/or amblyopia. The UK NSC recommends that all children should have VA measured monocularly and that children failing to achieve ≤0.2logMAR in both eyes should be referred for follow-up testing.[1]

World-wide population based studies have reported a prevalence of presenting visual impairment (PVI, defined as VA of >0.30 logMAR, in the better eye, using spectacles if worn) in children between 0.9 – 1.8%.[2-4] The factors associated with reduced VA are known to vary between populations[2,3,5-7] with the prevalence of refractive error differing between ethnic groups; for example, a higher prevalence of hypermetropia and myopia has been reported in white[8] and East Asian[9] populations, respectively. The prevalence of strabismus has been reported to vary between 1%[10] and 3%[11], and both the prevalence and type of strabismus has been shown to differ between ethnic groups, with esotropia being more common in children of white ethnicity[12,13] and exotropia more common in African-American[11] and East-Asian populations.[10]

The 2011 census indicated that 6% of the UK population was of South Asian origin; this is the fastest growing ethnic group in the UK.[14] Ethnicity along with other factors such as socio-economic status, maternal life-style choices and prematurity are risk factors associated with amblyopia,[7] strabismus[15] and other ophthalmic conditions[16] with the potential to affect visual development.

Population-specific prevalence data are required to inform service provision and knowledge of the risk factors associated with decreased VA in children will inform our understanding of causes and potentially modifiable factors. The aim of this study is to report the VA levels at the point of screening found in a UK multi-ethnic population using the VA referral criteria recommended by the UK NSC[1] (>0.20logMAR in one or both eyes) and explore maternal

and early-life factors associated with failing vision screening . A secondary aim is to report on the prevalence of presenting visual impairment (PVI, VA of >0.30 logMAR in the better eye)[2,4] in the population and again, to examine the associated factors.

METHODS

Study population

The population-based, vision screening programme in the city of Bradford, UK is offered annually to children commencing school aged 4-5 years. The programme achieves 97% coverage of the target population.[17] Screening is conducted in primary schools by orthoptists and includes VA measurement, cover test, and non-cycloplegic auto-refraction (Welch-Allyn Inc Skaneateles, New York, USA). VA is tested monocularly at 3 metres (with spectacles if worn) using the logMAR Crowded test (Keeler, Windsor, UK) with a letter matching card and is measured to threshold. For the purposes of this study, the results from all children failing to achieve the VA pass criterion set by the UK NSC[1] (≤ 0.2logMAR in both eyes) were examined. As per the local protocol, children who failed vision screening but with VA <0.70logMAR were referred for follow-up to a community optometrist of their choice. Those with ≥0.70logMAR were referred to the hospital eye service (HES). All the results from the vision screening programme were recorded and maintained on a secure server in the HES. Children failing the VA criterion at vision screening were referred initially for a cycloplegic refraction (1% cyclopentolate) and fundus examination undertaken either by a paediatric ophthalmologist or an optometrist, who based on the cycloplegic refraction result, determined whether spectacles were necessary, and if so, what the spectacle prescription should be. Children attending the HES had a follow-up appointment arranged with the orthoptist approximately 8 weeks after the cycloplegic examination to repeat the VA measurement, wearing any prescribed spectacles. Children assessed by a community optometrist had their examination results returned to the HES and also had a follow-up appointment arranged with the orthoptist. All VA testing, both at the point of vision screening and at follow-up, was performed using the same method of measurement described above.

The follow-up results including cycloplegic refraction, VA with the prescribed spectacles, cover testing and fundus and media examination were extracted from the medical notes following repeat testing. The programme data were collected over a three year period between 2012 and 2015.

Bradford is home to the Born in Bradford (BiB) birth cohort, following children born between 2007 and 2011. Details of recruitment have been published previously.[18] In order to explore potential risk factors for failing vision screening and PVI, the vision screening data were linked to data collected from the subset of mothers and children participating in BiB. For each child in the BiB cohort, data on gender, ethnicity, early life[7] (gestational age, route of birth, birth weight) and maternal factors[5] (age, education, smoking in pregnancy and whether receiving state benefits) were linked to the vision screening data. Ethics approval was obtained from the National Research Ethics Committee Yorkshire and the Humber- South Yorkshire UK (Ref 13/YH/0379) and the study was conducted according to the tenets of the Declaration of Helsinki.

Definitions

Presenting visual acuity (PVA) is the VA of the better eye with spectacles, if worn. Presenting visual impairment (PVI) is defined as VA of >0.3logMAR in the better eye with spectacles if worn.[2,4] Strabismus was diagnosed at follow-up from cover testing, (with and without any prescribed correction) and defined as any manifest deviation (constant or intermittent) at near (33cm) or distance (6M). A true positive is defined as VA, at the follow-up appointment with an Orthoptist, in the right or left eyes of >0.2logMAR and/or the presence of a significant refractive error confirmed on cycloplegic refraction and/or the presence of an associated ocular factor e.g. strabismus or ocular motility disorder. A false positive is defined as the absence of a significant refractive error, no associated ocular factor and VA of ≤0.2logMAR in the right and left eyes at follow-up. Based on the result of the cycloplegic refraction, refractive error was defined as follows;[19] low hypermetropia ≥+2.0D to +3.0D spherical equivalent refraction (SER) (sphere plus half cylinder), hypermetropia >+3.0D SER, myopia ≤-0.50D SER. Astigmatism is diagnosed when the cylindrical

component of the refractive error was ≥1.0D and emmetropia was defined as >-0.5D to <+2.0D SER in the absence of astigmatism. Failed to attend includes those children who were confirmed to have missed an appointment and also those children for whom there was no confirmatory record, either as notes were unavailable or there was no confirmation in the notes.

Statistical Analysis

Data are presented for all children participating in the annual vision screening programme between 2012 and 2015 in whom VA measures exist for both eyes. A description of the characteristics of the subset of children participating in BiB, including the distribution of early life, maternal risk factors and the VA is detailed. Univariable and multivariable logistic regression was used to further examine the associations between potential risk factors firstly using the pass/fail criterion for vision screening[1] and secondly for the criterion for PVI.[2,4] The factors selected were determined by previously reported literature and include maternal factors (ethnicity, age, level of education, in receipt of UK mean-tested benefits, smoked during pregnancy) and child factors (gender, route of birth, gestational age and low birth weight). Missing risk factor data were imputed using multiple imputation with chained equations[20] using 20 imputed data sets. A sensitivity analysis was performed on complete case, and the results showed similar patterns. Odds ratios (OR) and 95% confidence intervals (CI) are presented.

In order to estimate possible bias from loss to follow-up, the characteristics of BiB children who failed vision screening and subsequently attended for follow-up examination were compared with BiB children who were referred but who failed to attend, using either chi-square (categorical data) or t-tests (continuous data), respectively. The children who failed screening and who attended for follow-up were further categorised as true positives or false positives. The distribution of refractive error categories was examined for all children attending follow-up and then compared by ethnic group using Fisher's exact tests for the BiB

subgroup of children. All statistical analyses were carried out using STATA/SE software (Stata/SE 13 Windows, StataCorp LP, College Station, TX, USA).

RESULTS

Vision Screening

18332 children were eligible for screening over the study period and 17021 completed the screening (Figure 1). Of these, 380 children were unable to perform the letter matching test and 100 children had VA recorded for only one eye and were thus excluded from the analysis. The remaining 16541 children had a mean age at the time of testing of 60.07 (SD 4.55) months. Overall, 14074 (85.1%) children achieved VA ≤0.20 logMAR in the both eyes, and so 2467 (14.9%) were referred for follow-up, of these 775 were BiB children. 732 of the 16541 children (4.4%) had PVI (VA > 0.30 logMAR in the better eye) (Table 1). The mean VA of the right eye (RE) was 0.166 (SD 0.12) logMAR, and the left eye (LE) VA was 0.160 (SD 0.12) logMAR. 354/16541 (2.1%) children were wearing glasses at the time of vision screening, and of these 136/354 did not pass the screening. No difference was found in age at the time of testing between the children who passed versus those who failed the vision screening (mean diff -0.089 months; 95% CI: -0.28 to 0.10, p=0.35).

Risk factor analyses

Of the 16541 children screened, 5276 (31.8%) were BiB participants and thus had risk factor data available (Table 2). Table 3 shows the multivariable logistic regression analyses for the risk factors for failing vision screening and also having decreased PVI. The odds of failing vision screening based on the recommended pass/fail VA criteria increased in children of Pakistani origin (OR 1.83; 95% CI: 1.42 to 2.37) compared to white children. Children of low birth weight, children born to older mothers (Table 3) and children in families receiving benefits were also more likely to fail vision screening. A similar pattern was observed for the multivariable analysis exploring factors associated with PVI. Compared to white children, being of Pakistani origin (OR 2.49; 95% CI: 1.74 to 3.60) or of other ethnicity (OR 2.00; 95%

CI: 1.28 to 3.12) increased the odds of PVI. The factors significantly associated with failing vision screening, were also associated with presence/absence of PVI with the exception of being a child in a family in receipt of benefits (Table 3).

Follow-up

Of the 2467 children referred for follow-up no difference was found in the baseline PVA between those who attended follow-up compared to those who did not attend for follow up (mean diff -0.007; 95% CI: -0.02 to 0.007, p=0.36). In addition, comparison of the demographic and socio-economic factors, in particular ethnicity, of the BiB children who attended follow up and those who failed to attend was similar (Supplementary Information (SI).

The average time between screening and the follow-up appointment with spectacles was 23 (SD 18.38) weeks. 1068/2467 (43.3%) attended for follow-up, had their VA measured and had data available for both vision screening and the follow-up examinations, of these 457 were BiB children (Figure 1). 993/1068 (92.8%) children were true positives. 932/1068 (87.3%) children had the presence of significant refractive error confirmed and had been prescribed glasses (Figure 1). 92/1068 (8.6%) children followed-up had no significant refractive error; of these 17 had no associated condition, 15 had VA >0.2 in one eye and two had VA >0.2 in both eyes and were referred for additional testing e.g. electro-diagnostics. The remaining 75 emmetropic children (7% of the 1068 who attended after failing screening) were found at follow-up examination to have VA of ≤0.2logMAR in both eyes and to be without any significant refractive error or other associated condition. These children were classed as false positives; therefore 93% of those who failed vision screening were true positives.

351/457 (76.8%) of the BiB children who attended follow-up were found to have a significant refractive error. Of these, 133 (76.1%) had astigmatism which was the most frequent refractive error type (Table 4). Astigmatism alone or in combination with myopia was more frequent in the children of Pakistani origin compared to white children (Fisher's exact test,

p<0.001). Both low hypermetropia and hypermetropia were more common in white children, with other ethnicities occupying a middle position in both (Fisher's exact test, p<0.001).

DISCUSSION

This study presents a detailed profile of VA measured at vision screening in children aged 4-5 years. Linkage of the screening data with maternal and early-life data from the BiB birth cohort has allowed examination of factors associated with failing vision screening and those associated with PVI. It is one of very few cohort studies reporting a population of South Asian (mainly Pakistani origin) children. The yield from the screening was high, with 14.9% of the children failing to meet the UK NSC VA pass criteria[1] and 4% having PVI. The vision screening programme showed good positive predictive value (93%) with a false positive rate of only 7%, well within an acceptable standard.[21]

Our analyses show that ethnicity, mother's age at pregnancy and low birth weight are associated with both failing vision screening and PVI. Other population-based studies have reported factors such as ethnicity, gestational age, birth weight, the level of mother's education and her life style choices to be associated with a reduction in VA,[5] strabismus[15] and amblyopia.[7,19] Also, an Australian cohort study found an association between lower normative VA (VA levels in children without refractive error or ocular disease) and prematurity.[22]

The Bradford population is largely bi-ethnic with a high degree of homogeneity for both the Pakistani and white children, as well as having a small but significant proportion of children of other ethnicities[18] (Table 2). This has allowed robust and detailed analysis of the association of ethnicity with PVA in our population. We found that being a child of Pakistani origin had a strong association with failing vision screening (OR 1.83; 95% CI: 1.42 to 2.37) and PVI (OR 2.49; 95% CI: 1.74 to 3.60). In the UK, two studies in predominantly white populations report 0.6%[7] and 1.5%[4] of seven year old children with PVI. In a study in urban New Delhi,[23] 4.9% (comparable to our population) of South Asian children were found to have PVI; this differs from rural South India[24] where 2.6% of children were reported to have

PVI. The difference between the New Delhi and Southern India studies may be due to differences in the age of children, with those aged 5 to 7 years excluded from the latter study due to inability to perform the vision test. Leone et al,[22] reporting normative VA in preschool children, found East Asian children to have a lower mean VA compared to European or South Asian children of the same age and Merritt et al[25] report higher prevalence of decreased VA among African Americans (8.4%) compared to white American (4%) pre-school children. However, a number of studies reporting both normative VA[26] and decreased VA[2,3] in different populations have found no significant ethnic differences. Socio-economic factors have also been reported to be associated with VA. In a Scottish study children from the most deprived backgrounds were highly likely to fail vision screening compared to those from the least deprived backgrounds (OR 3.59, 95% CI 1.6 to 7.8, p=0.001)[27] and in the United States a study reported the socio-economic markers of lack of health insurance and lower educated mothers to be associated with bilateral decreased VA in pre-school children.[3] We found being in receipt of means tested benefits was associated with failing vision screening but not with PVI, possibly because of lower statistical power given the smaller number of children with PVI.

All children failing to meet the UK NSC pass criterion[1] were referred however, a significant number failed to attend (Figure 1). No socio-economic or demographic difference was found between the BiB children that failed to attend compared to those that attended follow-up (Supplementary Information).This may be due to the relative deprivation[28] within the local population.[18] Of those children who attended follow-up a large majority (87%) were found, following cycloplegic refraction, to require spectacles. This supports the case for all children failing vision screening to have a cycloplegic refraction to identify refractive error performed as part of the follow-up pathway. Our findings are similar to those of previous studies in which the presence of significant refractive error was found to be highly associated with reduced VA in young children.[2,5,6,27] We found that astigmatism alone or in combination with spherical ametropia was more common in children of Pakistani ethnicity (Fisher's exact $p<0.001$), and hypermetropia was more common in white children (Fisher's exact $p<0.001$).

In the UK, Fuller et al, studying a small sample of 62 children, reported higher prevalence (22.6%) of astigmatism in children of Bangladeshi origin compared to white children aged 4 – 5 years in two London schools.[29] The association of astigmatism with reduced VA has been reported in the combined findings of two large population based studies in the United States,[5] in which the odds of reduced VA were positively associated with the presence of astigmatism of >2.0 D (OR 17.6; 95% CI: 9 to 34.5). An Australian study of children of mainly white ethnicity has also reported astigmatism (≥1.0DC) as the principal refractive error leading to reduced VA.[2]

Similarly, the prevalence of hypermetropia is reported to vary between populations and between ethnic groups.[30] In the UK, a study of white children in Northern Ireland reported a 26%[4] prevalence of hypermetropia (≥3.00D) at age 6-7 years whilst a large cohort study in Bristol, UK reported a prevalence of just 5%[7] in children of mainly white ethnicity at the age of 7 years. The difference between the studies is likely to be due, at least in part, to the lack of cycloplegic refraction in the Bristol study. An Australian study[31] of 6 year old children, using cycloplegic auto refraction in a multi-ethnic population, reported 13.2% prevalence of hypermetropia (≥3.0D) in their population, with white children (15.7%) having an increased prevalence compared to children of other ethnicities (6.8%). An American study[8], also using cycloplegic auto-refraction, reported 8.9% of white children and 4.4% of African-American children to have hypermetropia (>3.0D).

We collected population-based screening data annually between 2012 and 2015. This large population base allows the presentation of VA levels with exploration and detailed analysis of associated risk factors for both failing vision screening and PVI. Both the initial VA measures at screening and the repeat VA measure at follow-up were collected by orthoptists with a high level of training and experience in VA measurement in young children, thus providing consistency of testing. However, this study has limitations. This paper presents data collected from clinical practice based on follow-up of 43.3% of the children referred, due to a combination of confirmed non-attendance and an inability to locate examination notes or to confirm attendance in medical notes. There is potential bias, particularly if one ethnic

group was less likely to attend or if the level of PVA differed between attenders and non-attenders. However, no significant difference was found in the PVA (mean diff: -0.007; 95% CI:-0.02 to 0.007) between children who attended and those who failed to attend, nor was a difference found for any demographic or socio-economic characteristic between BiB children who attended and those who failed to attend (SI). On this basis the VA levels and the relative frequency of refractive errors reported in the different ethnic groups of children who attended follow-up is likely to be representative of all children who failed screening.

The cycloplegic examination was undertaken by ophthalmologists or optometrists either in the community, or in the HES. The fact that cycloplegic refraction was conducted by a wide range of eye care professionals means that the examinations were not standardised, nor was there standardisation of the adjustment (if any) to the cycloplegic result in relation to what was prescribed. However this reflects clinical practice in the UK.

Children who passed the screening were not followed up preventing the identification of children who may actually have had a reduction in VA, thus we are not able to identify the proportion of false negatives in our sample.

An understanding of the prevalence, epidemiology and natural history of the target condition(s) is required to inform guidance and recommendations for national screening programmes. Identification of reduced VA is important in young children as it allows early detection and treatment of the related childhood eye disorders. Our study adds to current knowledge by providing robust prevalence data and valuable evidence of maternal and early life risk factors for failing vision screening and exhibiting PVI, highlighting the importance of the demographic profile of the target population. The high prevalence (4.4%) of PVI has implications for the planning and provision of vision screening programmes and the subsequent referral pathways to ophthalmological, orthoptic and optometry care. This study provides an epidemiological benchmark for similar urban populations and presents policy makers with information which will help in the planning of such services.

Acknowledgements: The authors thank all the families and schools who took part in this study, the orthoptists from Bradford Teaching Hospitals Foundation Trust who conducted the vision screening programme and the Data Support Team from Bradford Institute for Health Research who created and maintain the data linkage system.

Contributors: AB initiated the project, designed data collection, monitored data collection for the whole study, wrote the statistical analysis plan, cleaned and analysed the data, and drafted and revised the paper. She is guarantor. GS wrote the statistical analysis plan, cleaned and analysed the data and revised the draft paper. JAB, BTB, and MB contributed to the design of the study and revised the draft paper. TAS and JW initiated the project, contributed to the design of the study and revised the draft paper.

The authors declare that they have no conflict of interest.

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Figure 1: Participants flow chart describing the pathway and visual acuity levels of children participating in the Bradford vision screening programme.

BiB = Born in Bradford cohort study participants, VA= visual acuity, RE=right eye, LE= left eye, FTA=Child was confirmed to fail to attend an appointment, No confirmed record of attendance = No medical notes were available or no appointment date confirmed within the medical notes. *Visual acuity was retested with glasses where worn.

Table1. **Level of Presenting Visual Acuity in children participating in the vision screening programme (2012 to 2015).**

PVA Levels (logMAR)	n	(%)
better than 0.20 in both eyes	14074	85.10
better than 0.20 in one eye	985	5.95
worse than 0.20 in better eye		
>0.20 to ≤0.30	750	4.53
>0.30 to ≤0.40*	410	2.48
>0.40 to ≤0.50*	166	1.00
>0.50*	156	0.94
Total	16541	100.00

PVA = presenting visual acuity, calculated as the visual acuity (VA) of the better seeing eye with glasses if worn. * Children with >0.30 logMAR in the better seeing eye are defined as having PVI (presenting visual impairment).

Table 2. Description of maternal and child characteristics of the participating children who were also BiB participants (n=5276).

Characteristics	N (%)
Maternal	
Ethnicity	
White British	1677 (31.8)
Pakistani	2139 (40.5)
Other	577 (10.9)
Data Missing	883 (16.7)
Age (years)	
<25	1751 (33.2)
25-29	1766 (33.5)
30+	1759 (33.3)
Data Missing	0 (0.0)
Education	
<A level or other	2370 (44.9)
A level and above	1861 (35.3)
Data Missing	1045 (19.8)
Receives mean-tested benefits	
No	2444 (46.3)
Yes	1784 (33.8)
Data Missing	1048 (19.9)
Smoked during pregnancy	
No	3535 (67.0)
Yes	696 (13.2)
Data Missing	1045 (19.8)
Child	
Gender	
Male	2582 (48.9)
Female	2694 (51.1)
Data Missing	0 (0.0)
Route of birth	
Vaginal	4045 (76.7)
Caesarean	1156 (21.9)
Data Missing	75 (1.4)
Gestational age	
<37 weeks	295 (5.6)
37+ weeks	4906 (93.0)
Data Missing	75 (1.4)
Low birth weight (<2.5kg)	
No	4776 (90.5)
Yes	425 (8.1)
Data Missing	75 (1.4)
Visual acuity (logMAR)	mean (SD)
Right eye*	0.16 (0.12)
Data Missing	8 (0.2)
Left eye*	0.16 (0.12)
Data Missing	77 (1.5)

*VA measures are those taken at vision screening, not follow-up. BiB= Born in Bradford.

Table 3. Risk factor analyses for two visual acuity levels at vision screening §; (1) Pass/Fail vision screening and (2) PVI (VA in better eye of >0.3logMAR).

Risk Factor		OR (95% CI) Fail vision screening†	OR (95% CI) PVI ‡
Ethnicity	White British	1.00	1.00
	Pakistani	1.83 (1.42, 2.37)***	2.49 (1.74, 3.60)***
	Other	1.39 (0.98, 1.99)	2.00 (1.28, 3.12)**
Maternal age (years)	<25	1.00	1.00
	25-29	1.41 (1.12, 1.77)**	1.59 (1.17, 2.18)**
	30+	1.53 (1.21, 1.92)***	1.63 (1.19, 2.24)**
Maternal education	Less than A-level	1.00	1.00
	A-level and above	0.94 (0.76, 1.16)	0.92 (0.70, 1.21)
Receipt of benefit	No	1.00	1.00
	Yes	1.28 (1.04, 1.58)*	1.27 (0.92,1.69)
Smoked during pregnancy	No	1.00	1.00
	Yes	1.22 (0.89, 1.69)	1.46 (0.93,2.30)
Gender	Male	1.00	1.00
	Female	0.94 (0.79, 1.12)	1.01 (0.79,1.28)
Gestational age	<37 weeks	0.69 (0.45, 1.07)	1.08 (0.86,1.14)
Low Birth weight	<2.5kg	1.83 (1.33, 2.52)***	1.52 (1.00,2.34)*
Route of birth	Vaginal	1.00	1.00
	Caesarean	0.82 (0.66,1.02)	0.91 (0.68, 1.22)

* $p < 0.05$, ** $p < 0.01$, *** $p < 0.001$

§The analyses uses imputed data for the screened children who were BiB participants (n=5276).

†Fail vision screening (VA in one or both eyes of >0.2 logMAR) vs VA in both eyes of ≤0.2logMAR (pass).

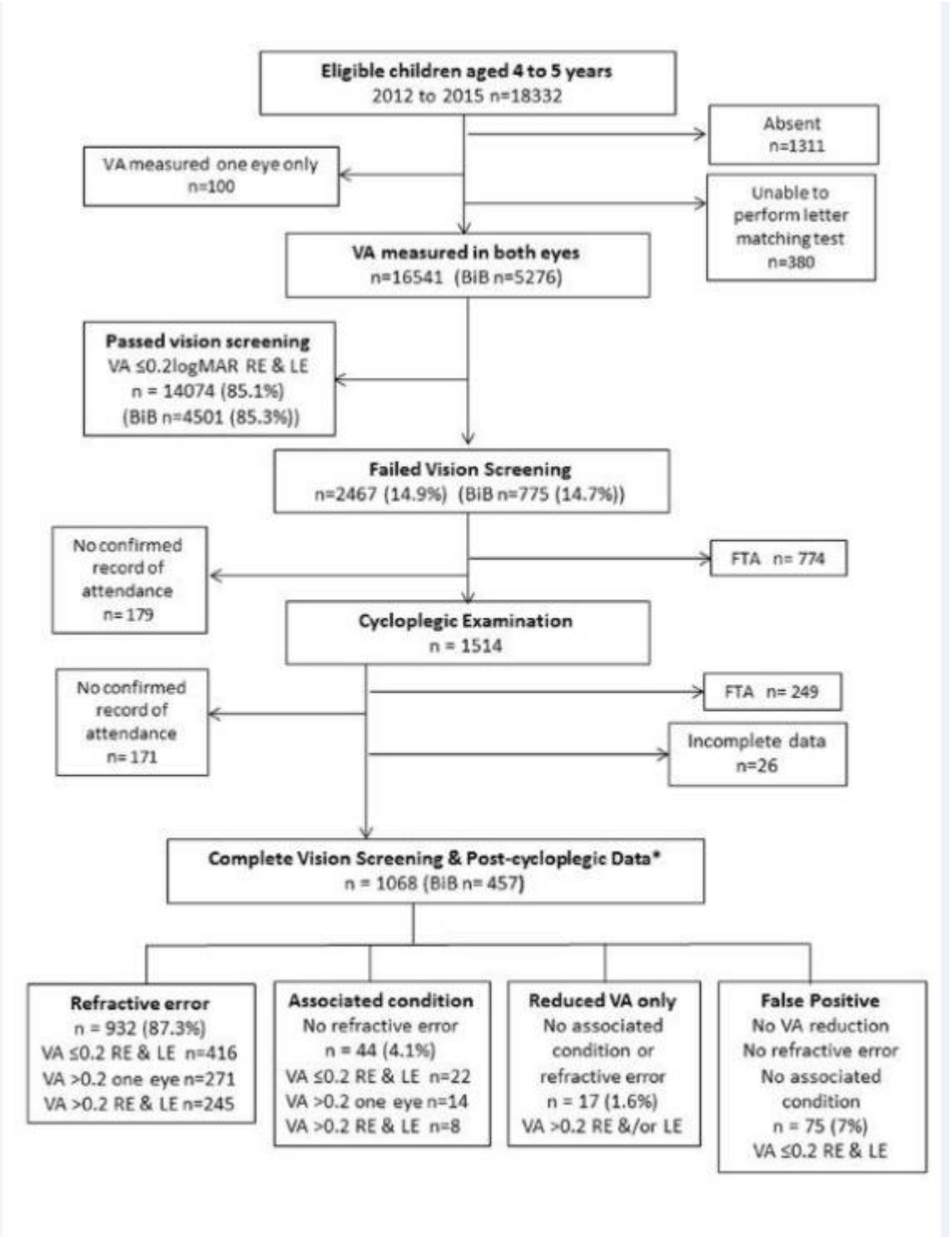
‡ PVI (VA >0.3logMAR in better eye) vs ≤0.3logMAR in better eye.

Table 4. Numbers (percentage) of BiB children in each refractive category (confirmed at cycloplegic refraction) according to their ethnicity.

	All n=351 n (%)	**White British n=104 n (%)**	**Pakistani n=203 n (%)**	**Other n= 44 n (%)**	**P-value†**
Refractive error n=351*					
Hypermetropia only (SER > +3DS)	48 (13.68)	28 (26.9)	14 (6.90)	6 (13.64)	<0.001
Hypermetropia & astigmatism combined	36 (10.26)	15 (14.42)	18 (8.87)	3 (6.82)	0.417
Low Hypermetropia only (SER > +2DS & ≤ +3DS)	22 (6.27)	16 (15.38)	4 (1.97)	2 (4.55)	<0.001
Low Hypermetropia & astigmatism combined	28 (7.98)	9 (8.65)	13 (6.40)	6 (13.64)	0.186
Myopia only (SER ≤ -0.50D)	14 (3.99)	1 (0.96)	10 (4.93)	3 (6.82)	<0.001
Myopia & Astigmatism combined	70 (19.94)	8 (7.69)	55 (27.10)	7 (15.91)	<0.001
Astigmatism only (> 1.0 DC)	133 (37.89)	27 (25.96)	89 (43.84)	17 (38.64)	<0.001

** subset of BiB children with refractive error by ethnicity only available for BiB children.

† Difference between White British, Pakistani and other ethnicities (Fisher's exact).


Eligible children aged 4 to 5 years
2012 to 2015 n=18332
Absent
n=1311
VA measured one eye only
n=100
Unable to perform letter matching test
n=380
VA measured in both eyes
n=16541 (BiB n=5276)
Passed vision screening
VA ≤0.2logMAR RE & LE
n = 14074 (85.1%)
(BiB n=4501 (85.3%))
Failed Vision Screening
n=2467 (14.9%) (BiB n=775 (14.7%))
No confirmed record of attendance
n=179
FTA n= 774
Cycloplegic Examination
n = 1514
No confirmed record of attendance
n= 171
FTA n= 249
Incomplete data
n=26
Complete Vision Screening & Post-cycloplegic Data*
n = 1068 (BiB n= 457)
Refractive error
n = 932 (87.3%)
VA ≤0.2 RE & LE n=416
VA >0.2 one eye n=271
VA >0.2 RE & LE n=245
Associated condition
No refractive error
n = 44 (4.1%)
VA ≤0.2 RE & LE n=22
VA >0.2 one eye n=14
VA >0.2 RE & LE n=8
Reduced VA only
No associated condition or refractive error
n = 17 (1.6%)
VA >0.2 RE &/or LE
False Positive
No VA reduction
No refractive error
No associated condition
n = 75 (7%)
VA ≤0.2 RE & LE

Supplementary Information. Characteristics of the subset of BiB children referred from vision screening comparing attended vs failing to attend.[§]

Characteristic		Attended follow-up N (%)	Failed to attend follow-up N (%)	Attended vs Failed to attend follow-up p-value
Age ‡ n=684	months	468 (68.42)	216 (31.58)	0.503
Presenting VA † n=684	logMAR	468 (68.42)	216 (31.58)	0.635
Ethnicity n=539	White British	106 (28.57)	44 (26.19)	0.634
	Pakistani	218 (58.76)	98 (58.33)	
	Other	47 (12.67)	26 (15.48)	
Maternal age n=684	<25 years	126 (26.92)	70 (32.41)	0.080
	25-29 years	156 (33.33)	79 (36.57)	
	30+ years	186 (39.74)	67 (31.02)	
Maternal education n=518	Less than A-level	205 (57.26)	94 (58.75)	0.752
	A-level and above	153 (42.74)	66 (41.25)	
Receipt of benefit n=519	Yes	165 (46.22)	82 (50.62)	0.352
	No	192 (53.78)	80 (49.38)	
Smoked during pregnancy n=518	Yes	52 (14.57)	23 (14.29)	0.933
	No	305 (85.43)	138 (85.71)	
Gender n=684	Male	233 (49.79)	111 (51.39)	0.697
	Female	235 (50.21)	105 (48.61)	
Gestational age n=679	<37 weeks	24 (5.17)	16 (7.44)	0.243
	≥37weeks	440 (94.83)	199 (92.56)	
Low Birth weight n=679	<2.5kg	46 (9.91)	32 (14.88)	0.059
	≥2.5kg	418 (90.09)	183 (85.12)	

§ = analysis of 684 of 775 BiB children who had confirmation of either attendance or FTA. Characteristics of children who attended vs FTA were compared using chi-squared or *t-test.*
‡ mean diff: 0.247 months (-0.476 to 0.970)
† mean diff: -0.0055 logMAR (-0.28 to 0.017)