



**University of Dundee**

**Long-term visual and treatment outcomes of whole-population pre-school visual screening (PSVS) in children**

O'Colmain, Una; Neo, Yan Ning; Gilmour, Claire; MacEwen, Caroline J.

*Published in:*  
Eye

*DOI:*  
[10.1038/s41433-020-0821-4](https://doi.org/10.1038/s41433-020-0821-4)

*Publication date:*  
2020

*Document Version*  
Peer reviewed version

[Link to publication in Discovery Research Portal](#)

*Citation for published version (APA):*

O'Colmain, U., Neo, Y. N., Gilmour, C., & MacEwen, C. J. (2020). Long-term visual and treatment outcomes of whole-population pre-school visual screening (PSVS) in children: a longitudinal, retrospective, population-based cohort study. *Eye*, 34, 2315-2321. <https://doi.org/10.1038/s41433-020-0821-4>

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1 **SUMMARY**

2 **What was known before**

- 3 • Pre-school visual screening is effective in identifying children at risk of amblyopia and  
4 is recommended to be offered for all children aged 4 to 5 years.
- 5 • Children who are socioeconomically deprived and those who come from homes that  
6 require high levels of social care input are more likely to fail visual screening.

7 **What this study adds**

- 8 • Long term outcomes of orthoptic delivered preschool visual screening demonstrate  
9 no difference in best corrected visual acuity (BCVA) and/or binocular vision (BV)  
10 outcomes based on socioeconomic deprivation alone – compliance with hospital  
11 attendance rates is more critical.
- 12 • Children from homes where extra social care support is required attend less well and  
13 are more likely to have poorer long-term visual outcomes.

14

15 Title: Long-term visual and treatment outcomes of whole population Pre-school  
16 Visual Screening (PSVS) in children: a longitudinal, retrospective, population-based  
17 cohort study

18 Running title: Long-term outcomes of Pre-School Visual Screening

19

20 Corresponding author:

21 **Dr Una O'Colmain**

22 Department of Ophthalmology

23 Ninewells Hospital and Medical School,

24 Dundee, Scotland, United Kingdom

25 Email: uocolmain@nhs.net

26

27 Co-authors:

28 **Dr Yan Ning Neo**

29 Moorfields Eye Hospital

30 Moorfields Eye Hospital NHS Foundation Trust,

31 162 City Road

32 EC1V 2PD London

33

34 **Miss Claire Gilmour**

35 Department of Orthoptics

36 Ninewells Hospital and Medical School,

37 Dundee, Scotland, United Kingdom

38

39 **Professor Caroline J MacEwen**

40 Department of Ophthalmology

41 Ninewells Hospital and Medical School,

42 Dundee, Scotland, United Kingdom

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44

45 **ABSTRACT**

46 **Background**

47 This study reports the long-term visual and treatment outcomes in a whole-population,  
48 orthoptic-delivered Pre-school Visual Screening (PSVS) programme in Scotland and further  
49 examines their associations with socioeconomic backgrounds and home circumstances.

50

51 **Methods**

52 Retrospective case review was conducted on 430 children who failed PSVS. Outcome  
53 measures included best corrected visual acuity (BCVA), severity of amblyopia (mild,  
54 moderate and severe), binocular vision (BV) (normal, poor and none), ophthalmic diagnosis  
55 and treatment modalities. Parameters at discharge were compared to those at baseline and  
56 were measured against the Scottish Index of Multiple Deprivation (SIMD) and Health Plan  
57 Indicator (HPI), which are indices of deprivation and status of home circumstances.

58

59 **Results**

60 The proportion of children with amblyopia reduced from 92.3% (373/404) at baseline to  
61 29.1% (106/364) at discharge ( $p < 0.001$ ). 80.0% (291/364) had good BV at discharge  
62 compared to 29.2% (118/404) at baseline ( $p < 0.001$ ). Children from more socioeconomically  
63 deprived areas (OR 2.19, 95% CI 1.01-4.30,  $p = 0.003$ ) or adverse family backgrounds (OR  
64 3.94, 95% CI 1.99-7.74,  $p = 0.002$ ) were more likely to attend poorly and/or become lost to  
65 follow-up. Children from worse home circumstances were 5 times more likely to have  
66 residual amblyopia (OR 5.37, 95%CI 3.29-10.07,  $p < 0.001$ ) and 3 times more likely to have  
67 poor/no BV (OR 3.41, 95%CI 2.49-4.66,  $p < 0.001$ ) than those from better home  
68 circumstances.

69

70 **Conclusion**

71 Orthoptic-delivered PSVS is successful at screening and managing amblyopia. Children  
72 from homes requiring social care input are less likely to attend and are more likely to have  
73 poorer visual outcomes.

74

75 **Keywords: Vision disorders, Refractive errors, Ocular motility disorders, Paediatrics,**  
76 **health care economics**

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92 **INTRODUCTION**

93 Amblyopia is the commonest vision deficit in children in the United Kingdom and is  
94 recognised to negatively impact the development of binocular vision (BV) and stereopsis.[1-  
95 4]

96 The pre-school milestone (age 4-5 years) is considered the most effective time to perform  
97 vision screening.[5,6] Binocular function develops from the age of 3 to 4 months and fully  
98 matures by the age of 8 to 9 years.[7] Although amblyopia screening is recommended by the  
99 National Screening Committee and the Hall (Four) Report,[8,9] its implementation has not  
100 been without considerable variation in terms of delivery policies, screening uptake and  
101 diagnostic pathways across the United Kingdom.[10,11] In view of the heterogeneity of  
102 existing screening programmes and scarcity of evidence on treatment outcomes, there is a  
103 need for population-based studies of long-term screening outcomes.[3,11,12]

104 The PSVS in Tayside is a whole population orthoptic-delivered programme for 4 to 5-year-  
105 old children. Previously we reported the increased likelihood of failing screening for children  
106 who are socioeconomically deprived and those who come from high risk homes where social  
107 care input is required.[13] The aim of this current study is to report the long-term visual  
108 outcomes of these children and to examine these with regard to socioeconomic and family  
109 circumstances.

110

111 **METHODS**

112 **Setting and study design**

113 Details of the PSVS offered across Tayside, East of Scotland were reported in our previous  
114 study.[13] Screening is delivered by orthoptists and when a child fails screening, he or she is  
115 referred for repeat orthoptic assessment, cycloplegic refraction and fundus examination. The  
116 vision standard to pass PSVS is best corrected visual acuity (BCVA) of  $\leq 0.2$  logMAR on

117 crowded Keeler test with each eye, or  $\leq 0.1$  logMAR with crowded Kay pictures if letter  
118 testing is not achieved. Children with significant refractive error are prescribed glasses and  
119 reviewed in the orthoptic clinic after up to 16 weeks; amblyopia therapy, if required, includes  
120 occlusion or atropine penalization. Children who are treated for amblyopia are examined  
121 every 6-8 weeks until BCVA improves to an age-appropriate level or is stable and deemed  
122 unlikely to improve further.

123 The study group comprised the same 523 children who failed PSVS from a total number of  
124 4365 (11.9%) children screened between March 2010 and February 2011 (as in our previous  
125 study).[13] A retrospective case review was performed to identify visual outcomes for each  
126 child up until either their final discharge visit, or most recent outpatient visit whichever came  
127 later. Outcome measures included BCVA, refractive status, residual amblyopia (if any) and  
128 BV. As we have previously reported on the rate of screening uptake and reasons for failing  
129 screening, these are not included in our current report.[13] In the event when a child had  
130 bilateral amblyopia, data from the worse seeing eye was used to avoid inter-eye correlations.  
131 Given the study was not conducted in a trial setting, there is no standard operating  
132 procedures for orthoptic appointments as the orthoptists work as autonomous practitioners  
133 who pick the most appropriate test for examination depending on the child's level of  
134 cooperation and vision on the day of visit.

135 Ninety-three children either did not attend any clinic appointments after the screening event  
136 or no follow-up data were available, leaving 430 children with clinical information on both  
137 their screening and subsequent follow-up appointments. Children who failed to attend were  
138 offered two further appointments before being discharged via letter to their general  
139 practitioner (GP) and health visitor (HV). This is summarised in **figure 1**. Of the 430 children  
140 who were seen after the screening event, 40 failed to attend before treatment was  
141 completed. This group of children was categorised as poor attenders and their last recorded  
142 visual outcomes were used for a separate analysis.

143

144 **Definitions**

145 *Scottish Index of Multiple Deprivation (SIMD)*

146 The SIMD 2012 (Scottish Government) is a multidimensional indicator, taking account of  
147 seven domain scores to produce an overall deprivation score for different postcodes. In our  
148 series of case studies, we have divided the SIMD into two distinct groups to examine the link  
149 between extreme deprivation and long term visual outcomes: Quintile 1 (0-20% most  
150 deprived) and Quintiles 2-5 (20-100% least deprived).

151

152 *Health Plan Indicator (HPI)*

153 This is a unique code given by the assigned HV of every child in the UK based on a  
154 comprehensive assessment of the needs of children and individual family circumstances.  
155 Three HPI codes were used at the time of this study and they, in order of increasing need for  
156 input from health and social services are Core (C), Additional (A) and Intensive (I). A child  
157 from a stable home with no concerns would be assigned 'Core' and receive HV and GP  
158 input; a child from an unstable home, for example with substance abuse problems, could be  
159 assigned 'Intensive' and subsequently receive more input from health and social services.  
160 The HPI is the only formally applied measure of the stability and security of a child's home  
161 environment, it is widely used and well validated.

162

163 *Strabismus*

164 Full orthoptic assessment of strabismus was undertaken, strabismus included any constant  
165 or intermittent heterotropia, and micro-strabismus.

166

167



168 *Amblyopia*

169 We defined amblyopia as BCVA  $\geq 0.2$  logMAR in the amblyopic eye and/or interocular  
170 difference of 3 or more logMAR lines. We excluded children with co-existing ocular  
171 abnormalities precluding normal vision. For children with bilateral amblyopia, visual acuity of  
172 the worse eye at baseline was used for comparison purposes.

173 We categorised amblyopia severity into three categories based upon the worse eye BCVA  
174 using the US Pediatric Eye Disease Investigator Group (PEDIG) definitions[14]; Mild: better  
175 than 0.3 logMAR; Moderate: 0.3-0.7 logMAR; Severe: worse than 0.7 logMAR.

176

177 *Binocular vision (BV)*

178 At the screening event, the orthoptists indicated “yes” or “no” for BV based on a child’s  
179 response to a 15 $\Delta$  prism reflex test and screening TNO plates. BV was further assessed at  
180 all clinic appointments. Frisby stereo-acuity test was used to assess stereopsis and Wirt fly  
181 was used if Frisby was not achieved. Motor fusion was assessed using the 15 or 20 $\Delta$  base  
182 out test. When BV was not performed at the discharge visit, the final recorded BV closest to  
183 a child’s discharge visit was used for comparison with the BV recorded at the first orthoptic  
184 visit which was subsequent to refraction and fundus check.

185 The range of BV was divided into three groups. Normal BV: Stereopsis better than 170  
186 seconds of arc and the ability to overcome a prism; Poor BV: stereopsis of 170 -600 seconds  
187 of arc irrespective of ability to overcome a prism or the inability to overcome a prism  
188 irrespective of level of stereopsis; No BV: Stereopsis poorer than 600 seconds of arc and the  
189 inability to overcome a prism.

190

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192

193 **Statistical analysis**

194 SPSS statistical package (IBM SPSS Statistics for Windows, V.19.0, IBM Corp, Armonk,  
195 New York, USA) was used for data analyses. Chi-squared test ( $\chi^2$ ) was used to calculate  
196 the association between categorical variables and socioeconomic background as well as  
197 home circumstance based on SIMD and HPI respectively. One-way analysis of variance was  
198 used to assess the difference in continuous variables among different subgroups.  
199 Hypothesis test of the equality of two proportions were used to compare proportions of  
200 amblyopia and BV. Mixed regression model was used to evaluate the relationship between  
201 BCVA and BV at discharge. All analyses were done with 95% confidence interval, and a p-  
202 value of  $\leq 0.05$  considered statistically significant.

203

204

205

206 **RESULTS**

207 **Study group and background demographics**

208 Results of the first clinic appointment (repeat orthoptic assessment, refraction and  
209 examination) were available for 430 of the 523 children (82.2%) who failed screening. The  
210 remaining 93 of the 523 children (17.8%) either did not attend their referral appointment from  
211 screening (Baseline visit) or there were no data available.

212 Of those who did attend their first appointment the attendance rate for follow-up at the eye  
213 clinic was 90.7% (390/430). Figure 1.

214 Background demographic and pattern of attendance to follow-up clinic visits are summarised  
215 in **Table 1**.

216

217 **Poor attenders**

218 Forty of the 430 children (9.3%) with follow-up results were categorised as poor attenders.

219 Mean ( $\pm$ standard deviation) age at discharge for this group was 6.2 $\pm$ 1.2 years old; their

220 mean duration of follow-up was 26.5 $\pm$ 10.5 months.

221 Sixteen (40.0%) of the 40 poor attenders were from the 0-20% most deprived socioeconomic

222 group. The odds of children from the 0-20% most deprived socio-economic group of having

223 poor attendance were twice as high as for those from the 20-100% least deprived

224 socioeconomic group (OR 2.19, 95% CI 1.01-4.30, p=0.003).

225 Eighteen (45.0%) of the 40 poor attenders were from a family assigned as either “Intensive”

226 (I) or “Additional” (A). The odds of children from HPI groups I and A of attending poorly were

227 four times higher than children from HPI group C (OR 3.94, 95% CI 1.99-7.74, p=0.002).

228

229 **Ophthalmic diagnosis**

230 Of the remaining 390 children who were regular attenders, 387 (99.2%) were discharged

231 from the clinic after a mean follow up time of 19.7 $\pm$ 5.8 months.

232 Twenty six of the 430 children (6.0%) who met the referral criteria were discharged after one

233 to two visits if their vision proved to be normal, these children were classed as false positives

234 and excluded from the outcome data. A further 31 (7.2%) children were reviewed at least

235 three times without any active intervention because they had reduced vision but no evidence

236 of refractive error or pathology and eventually they demonstrated a satisfactory level of

237 vision (VA <logMAR 0.2). These children were grouped as “visually immature” because with

238 age and repeated practice at the assessment they were able to achieve normal vision.

239 These children underwent cycloplegic refraction and dilated fundoscopy by a paediatric

240 ophthalmologist or hospital optometrist, as all our children do, and no pathology was found.

241 **Management**

242 Two hundred and fifty-four children were prescribed glasses; this was the sole intervention  
243 for 173 of the 390 children (44.4%) who attended regularly. 102 (26.1%) were treated with  
244 occlusion. Six children (1.5%) received atropine penalisation, 4 of whom had adjuvant  
245 patching. Two refused patching.

246 A total of twenty-four (6%) children were recorded as being non-compliant with either  
247 glasses (n=4) or occlusion (n=20), of which 10 were poor attenders and were lost to follow-  
248 up. Sixteen (66.7%) of these children were from a family assigned as “Intensive” or  
249 “Additional”. (OR 9.97, 95% CI 0.23-0.71, p<0.001). Five (20.8%) were from the 0-10% most  
250 socioeconomically deprived background.

251 Ten children (2.1%) received surgical correction for strabismus, for whom the mean overall  
252 length of follow-up in total was 3.08±1.40 years.

253

## 254 **Amblyopia**

255 The proportion of children with amblyopia at baseline and the final visit for both poor and  
256 regular attenders is shown in **figure 2**.

257 At baseline visit, 373 children (92.3%) had amblyopia. 62/373 (16.6%) were categorised as  
258 mild, 273/373 (73.1%) moderate and 38/373 (10.2%) severe.

259 For poor attenders (N=40) who were lost to follow-up, 72.5% had their last measured BCVA  
260 recorded as meeting the amblyopia threshold; of these 6 (15.0%) were categorised as mild,  
261 20 (50.0%) moderate and 3 (7.5%) severe.

262 For the remaining 364 children who attended clinic regularly, 70.9% children (n=258) had  
263 BCVA better than 0.2 logMAR at discharge. Difference between the proportion of children  
264 with amblyopia at baseline and at discharge was statistically significant (p<0.001).

265 The odds of having amblyopia at the baseline clinic visit was 29 times higher than at the  
266 point of discharge (OR 29.29, 95% CI 7.84-26.14, p<0.001). The odds of having residual

267 amblyopia for poor attenders was significantly higher than children who attended follow-up  
268 appointments regularly (OR 6.42, 95% CI 4.25-10.56,  $p<0.001$ ).

269

### 270 **Binocular vision**

271 At the point of screening 161 of 430 children (37.4%) who were referred had their BV  
272 recorded as “no”. At baseline orthoptic clinic visit, after refraction and fundus examination,  
273 118/404 (29.2%) had good BV, 185/404 (45.8%) had poor BV and 101/404 (25.0%) were  
274 recorded as no BV. Of the regular attenders, at discharge, 291/364 (79.9%) had good BV,  
275 49/364 (13.5%) had poor BV and 24/364 (6.6%) had no BV. The distribution of BV pattern  
276 proportion at baseline and at the final visit is summarised in **figure 3**.

277 The difference between the proportion of children with good BV at baseline and at discharge  
278 was statistically significant ( $p<0.001$ ). The odds of having good BV at discharge for the  
279 regular attenders was 7 times higher than that at baseline (OR 9.7, 95% CI 0.62-1.10,  
280  $p<0.001$ ). There was a positive association between BCVA and BV at final discharge  
281 ( $r=0.88$ , 95% CI 0.76-0.91,  $p<0.001$ ).

282 Of the 40 poor attenders, at baseline clinic visit, 8 (21.1%) had good BV, 21 (55.3%) had  
283 poor BV and had 9 (23.7%) had no BV. Twelve (31.6%) were last recorded as having good  
284 BV, 18 (47.4%) had poor BV and 8 (21.1%) had no BV.

285 The difference between the proportion of children having poor/no BV among the poor  
286 attenders compared to the regular attenders is significant ( $p<0.001$ ).

287

### 288 **Comparison of final visual outcome based on SIMD and HPI**

289 The relationship between socioeconomic background (SIMD), home circumstance as  
290 indicated by HPI and adverse visual outcome for children who attended well ( $n=364$ ) was  
291 examined (**Table 2**). Results were independent of gender and ethnicity for these children.

292 There was no statistical difference in the odds of children from the 0-20% most deprived  
293 socioeconomic background having poorer visual outcomes (final BCVA worse than logMAR  
294 0.2, improvement of BCVA less than logMAR 0.2 and poor or no BV) compared to children  
295 from the 20-100% least deprived socioeconomic background. ( $p=0.745$ ,  $p=0.710$ ,  $p=0.219$   
296 respectively).

297 However, children from HPI groups I and A were 5 times more likely to have a final BCVA  
298 worse than 0.2 logMAR (OR 5.37, 95%CI 3.29-10.07,  $p<0.001$ ) and 3 times more likely to  
299 have poor or no BV (OR 3.41, 95%CI 2.49-4.66,  $p<0.001$ ) compared to children from a  
300 family assigned as “Core”.

301

302

303

## 304 **DISCUSSION**

305 Overall the children in our real life cohort responded well to amblyopia treatment, with 70.9%  
306 of good attenders achieving a BCVA of better than 0.2 logMAR and 61.7% achieving an  
307 improvement of at least 0.2 logMAR. The proportion of children with moderate to severe  
308 amblyopia reduced from 77.0% at baseline to 8.7% at discharge. The magnitude of this  
309 improvement was comparable to that observed in randomised controlled trials such as the  
310 ALSPAC and PEDIG studies.[15,16]

311 Our results also demonstrated an increase in the proportion of children with good BV from  
312 29.2% at baseline to 79.9% at discharge. Previous studies have shown that BV can improve  
313 following treatment of amblyopia.[17-19] Our study supports these findings, including in  
314 those who had intermittent heterotropias and micro-strabismus.

315 This study found that children from more deprived socioeconomic backgrounds and those  
316 from families requiring more social care input (HPI) are more likely to have poor attendance.

317 Analysis of the visual outcomes for poor attenders in our study showed that they were 6  
318 times more likely to have residual amblyopia and almost 10 times more likely to have poor or  
319 no BV compared to regular attenders. Children who were poor attenders and those who  
320 became lost to follow-up record a relatively earlier last visit during their treatment, which  
321 meant they had fewer attempts to have improved visual acuity and less time to be treated in  
322 a closely monitored specialist setting. It is possible that poorer health seeking behaviour  
323 among parents who require social care input adversely impacts on the attendance rate of  
324 their children as they are less likely to engage with health services.[20] The attendance rate  
325 for follow-up eye clinic appointments in our study sits around 90.7%, which is higher than  
326 most other studies.[15,21]

327 Our results have demonstrated that irrespective of a child's socioeconomic background, with  
328 regular follow-up, intensive treatment and good compliance, children from more deprived  
329 backgrounds have similarly good visual outcomes compared to less deprived children. This  
330 is an important finding as our initial study found that children who were from deprived  
331 backgrounds were more likely to fail screening.[13] In this study, children from less stable  
332 home circumstances who required "Intensive" and "additional" support were 4.5 times more  
333 likely to have a worse final BCVA and 3 times more likely to have poor or no BV compared to  
334 children from the "core" group. This study also reported a similar association between worse  
335 home circumstances and screening outcomes.[13] Children from the "Intensive" and  
336 "additional" group were 10 times more likely to be treatment non-compliant, irrespective of  
337 socioeconomic background.

338 The reasons for this difference in screening failure rates are not known but it has been  
339 theorised that poorer prenatal/antenatal care [22, 23] associated with increased rates of  
340 maternal smoking, alcohol and drug intake [24, 25, 26, 27] which are commoner in deprived  
341 areas [28] may be significant contributors. This current study suggests that, if these factors  
342 are indeed relevant, they are reversible with adequate treatment. Comprehensive screening

343 to pick up these most vulnerable children is essential and it must be followed up by methods  
344 to encourage treatment compliance.

345 One limitation of our study was the retrospective nature of the data collection, but the benefit  
346 of this methodology is that the observational findings are representative of the real-life  
347 situation. The percentage of children lost to follow-up (9.3%) was slightly higher than other  
348 studies.[11,15-16] However, our results have shown that the majority of the poor attenders  
349 were from more socioeconomically deprived and adverse family backgrounds and that the  
350 home circumstances associated with poor attendance have the most impact on the outcome.  
351 Hence although this is a form of bias, it contributes to a possible underestimation of the  
352 negative impact of deprivation on the final visual outcome.

353 This study reports the treatment and visual outcomes of a whole population orthoptic-  
354 delivered preschool visual screening service. It identified that attendance is the key to the  
355 final visual outcome for children; children from deprived/high risk homes were much more  
356 likely to not attend appointments and did not do well. It is crucial for children who are already  
357 being brought up in a challenging environment that the screening system supports them and  
358 their families, in order that they may have the same successful outcomes as their more  
359 fortunate peers.

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366 **CONTRIBUTORS**

367 Data were collected by YN, UOC and CG. Statistical analysis was performed by YN. YN  
368 produced the initial draft manuscript, all authors contributed to the revision and UOC and  
369 CJM prepared the final draft.

370 **COMPETING INTERESTS**

371 None declared.

372

373 **FUNDING**

374 None

375

376 **ETHICS APPROVAL**

377 Ninewells Hospital Orthoptic and Ophthalmology departments have ongoing Caldicott  
378 guardianship approval for analysis and review of preschool vision screening outcomes.

379

380

381 **REFERENCES**

- 382 1. Grant S, Moseley MJ. Amblyopia and real-world visuomotor tasks. *Strabismus*  
383 2011;19(3):119-28
- 384 2. Levi DM, Knill DC, Bavelier D. Stereopsis and amblyopia: A mini-review. *Vision Res*  
385 2015;114:17-30
- 386 3. Powell C, Hatt SR. Vision screening for amblyopia in childhood. *Cochrane Database*  
387 *Syst Rev* 2009(3):CD005020
- 388 4. Carlton J, Karnon J, Czoski-Murray C, Smith KJ, Marr J. The clinical effectiveness  
389 and cost-effectiveness of screening programmes for amblyopia and strabismus in  
390 children up to the age of 4-5 years: a systematic review and economic evaluation.  
391 *Health Technol Assess* 2008;12(25):iii, xi-194
- 392 5. Taylor K, Elliott S. Interventions for strabismic amblyopia. *Cochrane Database Syst*  
393 *Rev* 2014(7):Cd006461
- 394 6. Taylor K, Powell C, Hatt SR, Stewart C. Interventions for unilateral and bilateral  
395 refractive amblyopia. *Cochrane Database Syst Rev* 2012(4):Cd005137
- 396 7. Espinosa JS, Stryker MP. Development and plasticity of the primary visual cortex.  
397 *Neuron* 2012;75(2):230-49
- 398 8. Committee NS. The UK NSC policy on vision defects screening in children. 2013
- 399 9. Hall DMB ED. Health for all children. Oxford University Press 2006
- 400 10. Touffeeq A, Oram AJ. School-entry vision screening in the United Kingdom: practical  
401 aspects and outcomes. *Ophthalmic Epidemiol* 2014;21(4):210-6
- 402 11. Solebo AL, Cumberland PM, Rahi JS. Whole-population vision screening in children  
403 aged 4-5 years to detect amblyopia. *Lancet* 2015;385(9984):2308-19
- 404 12. Schmucker C, Grosselfinger R, Riemsma R, Antes G, Lange S, Lagreze W, Kleijnen  
405 J. Effectiveness of screening preschool children for amblyopia: a systematic review.  
406 *BMC Ophthalmol* 2009;9:3

- 407 13. O'Colmain U, Low L, Gilmour C, MacEwen CJ. Vision screening in children: a  
408 retrospective study of social and demographic factors with regards to visual  
409 outcomes. *Br J Ophthalmol* 2016;100(8):1109-13
- 410 14. Repka MX, Kraker RT, Holmes JM, Summers AI, Glaser SR, Barnhardt CN et al. A  
411 randomized trial of atropine vs. patching for treatment of moderate amblyopia in  
412 children. *Arch Ophthalmol* 2002;120(3):268-78
- 413 15. Williams C, Northstone K, Harrad RA, Sparrow JM, Harvey I; ALSPAC Study Team.  
414 Amblyopia treatment outcomes after screening before or at age 3 years: follow up  
415 from randomised trial. *BMJ* 2002;324(7353):1549
- 416 16. Pediatric Eye Disease Investigator Group. Pharmacological plus optical penalization  
417 treatment for amblyopia: results of a randomized trial. *Arch Ophthalmol*  
418 2009;127(1):22-30
- 419 17. Awadein A, Fakhry MA. Changes in binocular function in anisometropic  
420 nonstrabismic children with optical correction and occlusion therapy. *J AAPOS*  
421 2011;15(6):545-50
- 422 18. Cleary M, Houston CA, McFadzean RM, Dutton GN. Recovery in microtropia:  
423 implications for aetiology and neurophysiology. *Br J Ophthalmol* 1998;82(3):225-31
- 424 19. Lee SY, Isenberg SJ. The relationship between stereopsis and visual acuity after  
425 occlusion therapy for amblyopia. *Ophthalmology* 2003;110(11):2088-92
- 426 20. MacKian S. A review of health seeking behaviour: problems and prospects. Health  
427 Systems Development Programme. 2003.
- 428 21. Williams C, Northstone K, Harrad RA, Sparrow JM, Harvey I; ALSPAC Study Team.  
429 Amblyopia treatment outcomes after preschool screening v school entry screening:  
430 observational data from a prospective cohort study. *Br J Ophthalmol* 2003;87(8):988-  
431 93
- 432 22. Tarczy-Hornoch K, Varma R, Cotter SA, McKean-Cowdin R, Lin JH, Borchert MS et  
433 al. Risk factors for decreased visual acuity in preschool children: the multi-ethnic

- 434           pediatric eye disease and Baltimore pediatric eye disease studies. *Ophthalmology*  
435           2011;118:2262-73
- 436       23. Gilbert CE, Ellwein LB. Refractive Error Study in Children Study Group. Prevalence  
437           and causes of functional low vision in school age children: results from standardized  
438           population surveys in Asia, Africa and Latin America. *Invest Ophthalmol Vis Sci*  
439           2008;49:877-81.
- 440       24. Chew E, Remaley NA, Tamboli A, Zhao J, Podgor MJ, Klebanoff M. Risk factors for  
441           esotropia and exotropia. *Arch Ophthalmol* 1994;112:1349-55.
- 442       25. Hakim RB, Tielsch JM. Maternal cigarette smoking during pregnancy: a risk factor for  
443           childhood strabismus. *Arch Ophthalmol* 1992;110:1459-62.
- 444       26. McGlone L, Hamilton R, McCulloch DL, MacKinnon JR, Bradnam M, Mactier H.  
445           Visual outcome in infants born to drug-misusing mothers prescribed methadone in  
446           pregnancy. *Br J Ophthalmol* 2014;98:238-45.
- 447       27. Spiteri Cornish K, Hrabovsky M, Scott NW, Myerscough E, Reddy AR. The short and  
448           long-term effects on the visual system of children following exposure to maternal  
449           substance misuse in pregnancy. *Am J Ophthalmol* 2013;156:190-4.
- 450       28. Davi-Gray A, Moor S, Spencer C, Woodward LJ. Psychosocial characteristics and  
451           poly-drug use of pregnant women enrolled in methadone maintenance treatment.  
452           *Neurotoxicol Teratol* 2013;38:46-52.

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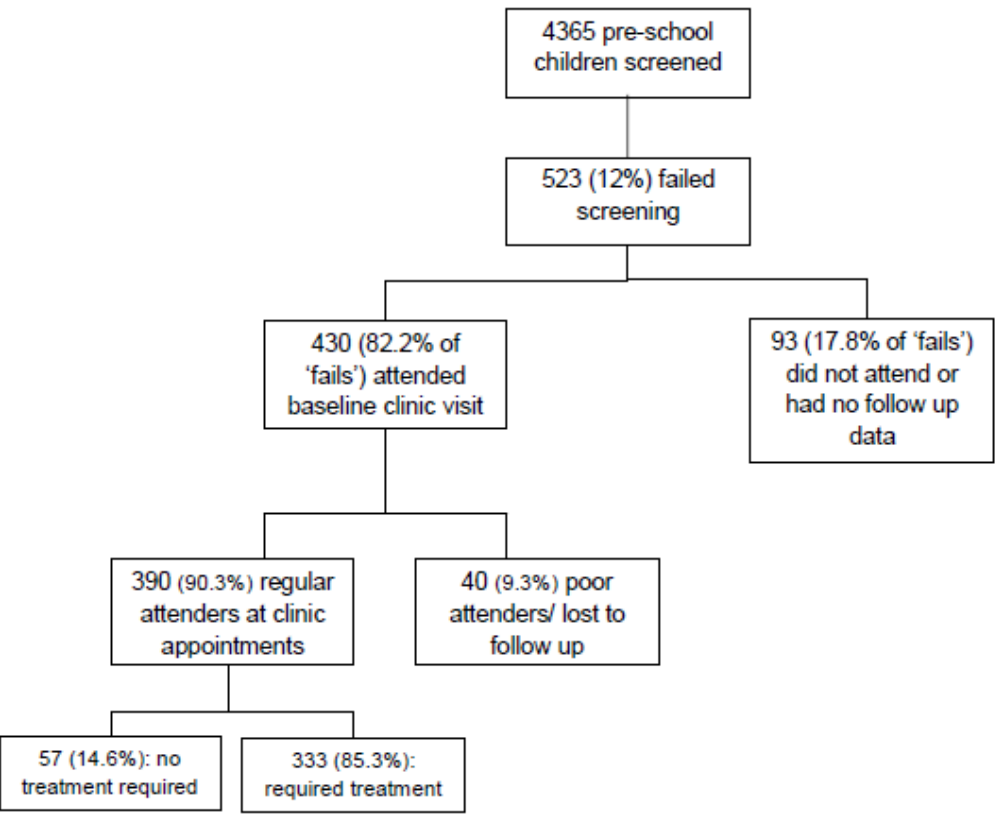
457 **Titles and legends to figures**

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459 Figure 1: Flow chart summarising the number of children who underwent Pre-school Visual  
460 Screening (PSVS) and number of children included in the final analysis of this study.

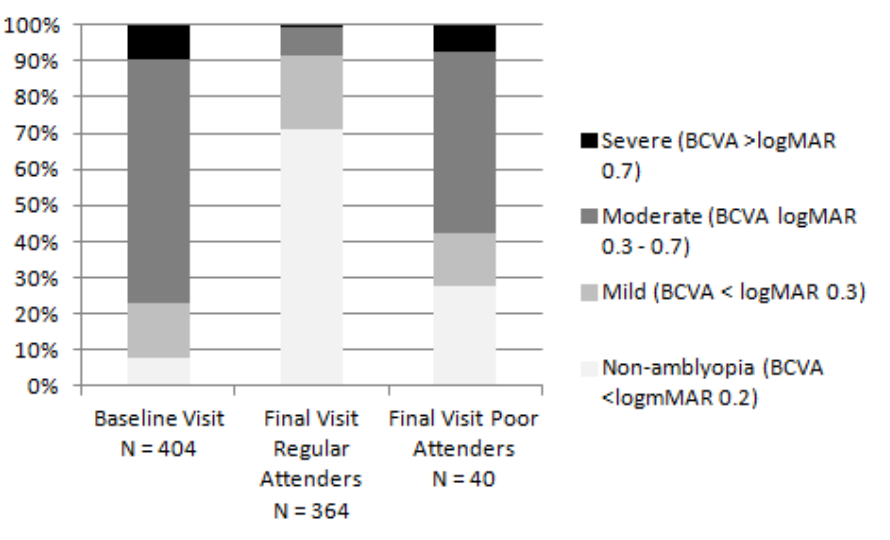
461 Figure 2: This graph shows the distribution of amblyopia based on the level of severity (mild,  
462 moderate and severe) at baseline and final visit for regular and poor attenders.

463 Figure 3: This graph shows the distribution of binocular vision (BV) at baseline and final visit  
464 for regular and poor attenders.

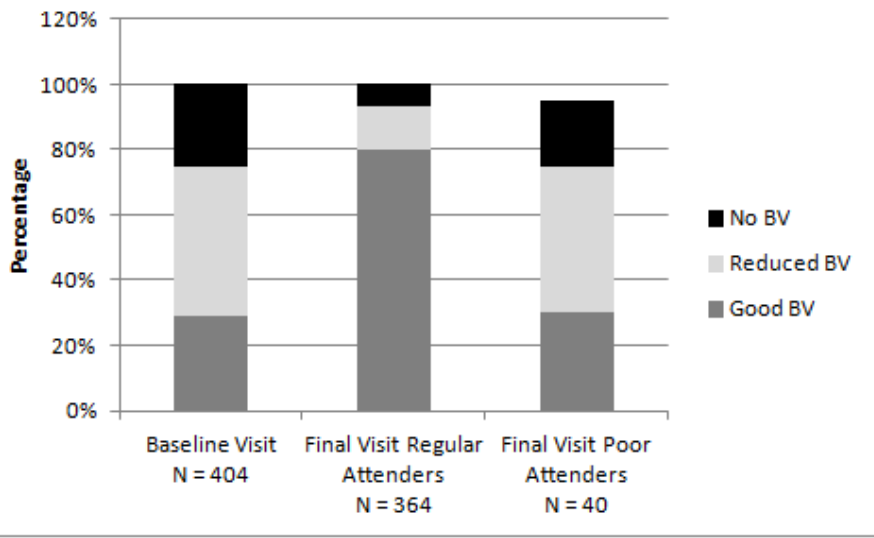


Scottish Index of Multiple Deprivation (SIMD)		No. (%) of children (n=430)
	Quintile 1 (Most deprived)	107 (24.9%)
	Quintile 2	62 (14.4%)
	Quintile 3	82 (19.1%)
	Quintile 4	130 (30.2%)
	Quintile 5 (Least deprived)	49 (11.4%)
Health Plan Indicator (HPI)		
	Intensive (I)	22 (5.1%)
	Additional (A)	63 (14.7%)
	Core (C)	345 (80.2%)
Attendance		
	Regular attender	390 (90.7%)
	Poor attender	40 (9.3%)
Gender		
	Male	207 (48.1%)
	Female	223 (51.9%)
Ethnicity		
	Caucasian	421 (97.9%)
	Others	9 (2.1%)

**Table 1:** This table details the background socioeconomic status, health plan indicator and pattern of attendance to follow-up clinic for study population







	Scottish Index of Multiple Deprivation (SIMD)				Health Plan Indicator (HPI)			
	Quintile 1 (0-20% most deprived)		Quintile 2-5 (20-100% Least deprived)		Intensive (I) and Advanced (A)		Core (C)	
	n (%)	OR (95% CI)	n (%)	p-value	n (%)	OR (95% CI)	n (%)	p-value
Final BCVA >logMar 0.2	22 (24.2%)	0.82 (0.48-1.40)	84 (28.1%)	0.745	40 (59.7%)	5.37 (3.29-10.07)	66 (20.4%)	<b>&lt;0.001</b>
Improvement of BCVA <logMar 0.2	31 (34.0%)	1.11 (0.68-1.82)	95 (31.8%)	0.710	25 (37.3%)	1.31 (0.76-2.27)	101 (31.3%)	0.264
Poor / No BV	21 (23.0%)	1.40 (1.19-3.94)	52 (17.4%)	0.219	25 (37.3%)	3.41 (2.49-4.66)	48 (14.9%)	<b>&lt;0.001</b>

**Table 2:** A comparison of the odds of children having poorer visual outcomes (final BCVA more than 0.2 logMAR, improvement of BCVA less than 0.2 logMAR and reduced/no binocular vision) based on recorded SIMD and HPI at discharge.