

# Research

## Does amblyopia affect educational, health, and social outcomes? Findings from 1958 British birth cohort

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### Abstract

**Objective** To determine any association of amblyopia with diverse educational, health, and social outcomes in order to inform current debate about population screening for this condition.

**Design, setting, and participants** Comparison of 8432 people with normal vision in each eye with 429 (4.8%) people with amblyopia (childhood unilateral reduced acuity when tested with correction and unaccounted for by eye disease) from the 1958 British birth cohort, with respect to subsequent health and social functioning.

**Results** No functionally or clinically significant differences existed between people with and without amblyopia in educational outcomes, behavioural difficulties or social maladjustment, participation in social activities, unintended injuries (school, workplace, or road traffic accidents as driver), general or mental health and mortality, paid employment, or occupation based social class trajectories.

**Conclusions** It may be difficult to distinguish, at population level, between the lives of people with amblyopia and those without, in terms of several important outcomes. A pressing need exists for further concerted research on what it means to have amblyopia and, specifically, how this varies with severity and how it changes with treatment, so that screening programmes can best serve those who have the most to gain from early identification.

### Introduction

Amblyopia (literally “blunt sight”) is potentially remediable visual loss, usually affecting one eye, arising from an insult (or insults) to the developing visual system in early life. It has long been the subject of basic scientific and clinical research aimed at understanding normal visual development and neural plasticity.<sup>1 2</sup> Centuries after the earliest writings, the management of amblyopia continues to challenge clinicians, remaining the most commonly encountered condition in paediatric ophthalmic practice. Whole population screening is now well established in many industrialised countries, aiming to detect affected children so that they can be treated within the “critical period.” This practice arose piecemeal—in Britain it emerged in the 1960s from a perceived need by professionals and has been implemented in various ways in the context of child health surveillance.<sup>3</sup> Recently formulated national guidance in the United Kingdom advocates screening of children aged 4–5 years (most easily achieved at school entry) by orthoptists with expertise in assessing vision and eye movements.<sup>4</sup> The value of screening has recently been much debated.<sup>3 5</sup> This partly reflects concerns about the paucity

of evidence of the functional consequences of amblyopia and their impact at a population level, a key factor in assessing the value of screening and its effectiveness. From a national cohort study, we report an investigation of the association of amblyopia with diverse health and social outcomes.

### Methods

The 1958 British birth cohort initially comprised everyone born in Britain in one week in 1958.<sup>6</sup> Members have been followed since birth, by clinical examination, interview, or both at 7, 11, 16, 23, 33, and 41 years. Data have been collected about many biological, social, and lifestyle factors. Despite some attrition, those cohort members remaining were representative of the original sample, including with respect to vision status.

By using Snellen charts, distance visual acuity in each eye was assessed with habitual correction at 7, 11, and 16 years, together with an examination for strabismus by trained medical examiners. Parents and medical examiners reported eye diseases or operations throughout childhood, including information about occlusion, strabismus surgery, and optical correction. For this analysis, we excluded people with bilateral visual loss, unilateral loss inconsistent with amblyopia, or known eye diseases (such as cataract), as well as those whose vision was tested without their prescribed optical correction. We identified and compared people who, at the age of 16, were in one of the following mutually exclusive “vision” categories, based on acuity tested with correction if prescribed: normal vision—acuity of 6/6 with or without correction in each eye throughout childhood; mild (“residual/persisting”) amblyopia—acuity of 6/6 in one eye and 6/9 or 6/12 in the other and unilateral visual loss, with or without strabismus, earlier in childhood; moderate or severe (“residual/persisting”) amblyopia—acuity of 6/6 in one eye and 6/18 or worse in the other and unilateral visual loss, with or without strabismus, earlier in childhood.

For completeness, we analysed separately those with “resolved” amblyopia—that is, with acuity of 6/6 in each eye at 16 years but with unilateral visual loss, with or without strabismus, earlier in childhood, all of whom had had treatment for amblyopia (see tables C and D on bmj.com).

In the absence of information about the functional consequences of amblyopia and their impact at a population level, we elected to investigate key outcomes across the life course in the spheres of education, occupation, and employment; general and mental health; and social interactions and



Tables A–D are on bmj.com

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behaviours, as a means of capturing any important functional correlates. We assessed the associations of amblyopia with:

- Education—age appropriate tests (described elsewhere<sup>7</sup>) of mathematics, reading, comprehension, and perceptual and motor skills at 7, 11, and 16 years, comparing standardised z scores as a measure of a given child's relative position in the population at each testing age
- Coordination—assessed by a medical examiner (heel to toe standing, finger-nose touching, finger tapping, catching a ball) at 16 years
- Highest educational qualification attained by 33 years (none, less than O level or equivalent, O level or equivalent, A level or equivalent, or higher)
- Behavioural difficulties or social maladjustment at school or at home—by convention the highest decile of scores on the Bristol social adjustment guides and Rutter scales<sup>8 9</sup> respectively at 7 and 11 years
- Participation in sport/outdoor games at 11, 16, and 23 years
- Social activities (going dancing or to the cinema, meeting friends) at 16 and 23 years
- Unintended injury needing hospital care, including at school, in the workplace, and road traffic accidents as a driver, between 11 and 33 years
- General health, self reported at 23, 33, and 41 years as excellent, good, fair, or poor
- Mental health, comprising self report of seeing a doctor for depression and psychological distress (a score of  $\geq 7$  on the malaise inventory<sup>9</sup>) at 23, 33, and 41 years
- Employment experience, comprising paid employment histories by 33 years
- Occupation,<sup>10</sup> comprising working, at age 33 years, in “target” jobs for which minimum visual acuity statutory requirements exist in the UK (table 1)<sup>11</sup>
- Differential impact on occupation based social class potentially related to job preclusion, assessed as change from “expected” social class to “actual” social class (Registrar General's classification) by comparing cohort members' father's occupation at birth and own occupation at 33 years and identifying three broad trajectories of no change, upward change, and downward change
- All cause mortality.

Of the outcomes assessed, educational attainment, employment, and unintended injuries could arguably be considered the main outcomes of interest in relation to the debate on the value of population screening.

## Statistical analysis

After initial descriptive analysis, we investigated amblyopia as a risk factor for adverse outcomes by using linear, logistic, or ordinal logistic regression techniques, as appropriate, and adjusting for factors considered from the extant literature to be potential confounders, including sex, birth weight, social class, and highest educational attainment. The sample eligible for inclusion in the study enabled at least 85% power to detect an adjusted odds ratio of 1.5 or more for people with mild amblyopia and an adjusted odds ratio of 2.0 or more for those with moderate or severe amblyopia for outcomes with a prevalence of 15% or more.

To ensure the independent effects of strabismus in itself were accounted for, we also adjusted analyses for ever having had a strabismus. We compared children with strabismus but normal (6/6) acuity bilaterally at ages 7, 11, and 16 (n = 183, 37.7% of all children with strabismus) with those with normal vision without strabismus; the outcomes did not differ, and we retained the first group in the “normal vision” category for analysis.

**Table 1** Occupations in United Kingdom with minimum visual acuity requirements<sup>11</sup>

Vision in worse eye with correction	Job excluded
Less than 6/60	Merchant Navy (engine room, radio staff, catering department, surgeon)
6/60	All army regiments
6/36	All Royal Navy duties
	Large goods vehicle driver
	Bus driver
	Post Office driver
	Metropolitan cab driver
6/18	Private pilot
	Train driver
	London Transport driver
	Fork lift truck driver
	Police
	Prison officer
	Commercial pilot
	Flight navigator
6/12	Flight engineer
	Air traffic control officer
	All non-flying Royal Air Force personnel
	Merchant seaman (deck duties)
	Life boat crew
	Royal Air Force pilot
6/9	Royal Air Force navigator
	Royal Air Force aircrew
	Fire brigade

## Results

We included in the study the 8861 people at age 16 who were eligible, of whom 53% (4653) were male. In all, 95.2% (8432) had normal vision and 4.8% (429) had residual/persisting amblyopia: 3.6% (320) mild and 1.2% (109) moderate or severe. One hundred and one (1.2%) had resolved amblyopia, and 4.3% (384) overall and 47% (201) of those with amblyopia had strabismus. For brevity, we present only key illustrative findings here (in particular for outcomes repeatedly assessed at different ages); tables A-D on [bmj.com](http://bmj.com) give the full dataset described above.

### Education and occupation

Children with amblyopia did as well as those with normal vision on educational tests (table 2 and table A). Amblyopia was not associated with highest educational qualification achieved (table 3). We found no association between amblyopia and being in paid employment at age 33 for men or women. Overall, 2321/3351 (69%) of men had experienced some degree of upward shift in social class; we found no evidence that those with amblyopia had a different pattern (upward shift in 69% for normal, 73% for mild, and 63% for moderate or severe amblyopia; P = 0.413).

Overall, people with amblyopia were as likely as those with normal vision to be in any “target” occupation.<sup>11</sup> Specifically, 7.7% (95% confidence interval 6.7% to 8.6%) of men with normal vision and 5.7% (1.8% to 9.6%) of those with amblyopia (P = 0.397 for difference in proportion) were in any of these occupational categories. As the total number of people with amblyopia was small (7 mild, 1 moderate/severe amblyopia), further formal analysis was not possible, but only the person with moderate/severe amblyopia failed to meet the visual standards for his current occupation.

### Behaviour and social functioning

Children with amblyopia were generally no more likely than those without amblyopia to have significant behavioural

**Table 2** Associations between mild or moderate/severe amblyopia and educational attainment during childhood

Education tests (at age 11)	Normal vision (No)	Amblyopia		Adjusted difference (95% CI) in scores*	P value
		Degree	No		
Maths†	5894	Mild	194	0.02 (−0.10 to 0.15)	0.705
		Moderate/severe	79	−0.09 (−0.29 to 0.11)	0.366
Reading†	5938	Mild	197	0.09 (−0.03 to 0.20)	0.151
		Moderate/severe	80	−0.14 (−0.14 to 0.24)	0.600
Copy-a-design†	5622	Mild	186	0.14 (−0.02 to 0.29)	0.078
		Moderate/severe	76	−0.11 (−0.35 to 0.13)	0.370
Verbal score on general ability test	5526	Mild	184	−0.34 (−1.70 to 1.01)	0.619
		Moderate/severe	73	−0.86 (−2.99 to 1.27)	0.427
Non-verbal score on general ability test	5525	Mild	184	−0.27 (−1.38 to 0.83)	0.630
		Moderate/severe	73	−0.03 (−1.77 to 1.71)	0.970

\*Normal vision minus amblyopia, adjusted for social class, sex, age at testing, family size, ever having strabismus, treatment for amblyopia, and previous test scores where appropriate.

†Standardised education scores—that is, multiples of standard deviation.

problems or maladjustment at home or school (table 4, table A). Specifically, they were no more likely to be bullied, as measured by the specific item in the Rutter scale, at 7 or 11 years (odds ratio 1.09, 0.59 to 2.00,  $P=0.781$  for mild at age 7; 1.51, 0.63 to 3.61,  $P=0.354$  for moderate/severe at age 7; 0.75, 0.36 to 1.60,  $P=0.462$  for mild at age 11; 0.62, 0.21 to 1.89,  $P=0.404$  for

moderate/severe at age 11; adjusted for sex, social class, and ever having had a strabismus). We found no evidence for an association between amblyopia and participation in social activities in either childhood or adult life (tables 3 and 4). Children with amblyopia were as likely as those with normal vision to play sport or outdoor games (table 4, table A). Overall, <1% had

**Table 3** Associations between mild or moderate/severe amblyopia and education, employment, social activities, unintended injuries, general and mental health in adult life

Outcome	Normal vision (No)	Amblyopia		Adjusted odds ratio (95% CI) (amblyopia v normal vision)	P value
		Degree	No (%) affected		
Education (at age 33)*					
Higher educational attainment	4965	Mild	184	1.22 (0.91 to 1.64)	0.189
		Moderate/severe	65	0.99 (0.61 to 1.61)	0.962
Employment (at age 33)†					
In paid employment (men)	2416	Mild	69/90 (77)	0.93 (0.55 to 1.60)	0.805
		Moderate/severe	22/33 (67)	0.51 (0.22 to 1.17)	0.112
In paid employment (women)	2502	Mild	59/91 (65)	0.92 (0.57 to 1.50)	0.747
		Moderate/severe	16/27 (60)	0.71 (0.31 to 1.64)	0.427
Sport and social functioning (at age 23)‡					
Not done any sport in previous month	6592	Mild	117/237 (49)	0.94 (0.71 to 1.26)	0.686
		Moderate/severe	41/82 (50)	1.07 (0.65 to 1.75)	0.800
Not been dancing in previous month	6592	Mild	101/238 (42)	1.00 (0.76 to 1.34)	0.954
		Moderate/severe	33/82 (40)	0.88 (0.54 to 1.44)	0.610
Not been to the cinema in previous month	6598	Mild	150/238 (63)	0.87 (0.65 to 1.16)	0.339
		Moderate/severe	49/82 (60)	0.76 (0.46 to 1.25)	0.283
General health (at age 33)§					
Self report of poorer health	3579	Mild	121	1.04 (0.73 to 1.49)	0.839
		Moderate/severe	51	1.12 (0.64 to 1.95)	0.700
Mental health (at age 33)¶					
Depression, seen general practitioner or specialist in past 10 years	3578	Mild	21/120 (18)	1.54 (0.93 to 2.56)	0.093
		Moderate/severe	8/50 (16)	1.61 (0.74 to 3.53)	0.233
Psychological distress (malaise inventory score >7)	3471	Mild	9/117 (8)	0.88 (0.41 to 1.90)	0.754
		Moderate/severe	4/49 (8)	1.29 (0.44 to 3.79)	0.649
Unintentional injuries (at age 17-33)‡					
Inpatient care	5355	Mild	33/198 (17)	1.56 (1.03 to 2.38)	0.037
		Moderate/severe	9/72 (13)	1.09 (0.50 to 2.40)	0.826
Outpatient care	5356	Mild	104/198 (53)	0.90 (0.65 to 1.24)	0.517
		Moderate/severe	44/72 (61)	1.04 (0.60 to 1.82)	0.882
Road accident as driver	5390	Mild	39/200 (20)	1.28 (0.87 to 1.89)	0.210
		Moderate/severe	22/72 (31)	2.33 (1.29 to 4.20)	0.005
Injury at work	5390	Mild	39/200 (20)	0.78 (0.52 to 1.17)	0.226
		Moderate/severe	17/72 (24)	0.76 (0.40 to 1.45)	0.408

\*Ordinal regression—odds of achieving higher level of education, independent of actual level considered, adjusted for sex, social class, marital status, ever having strabismus, and treatment for amblyopia.

†Adjusted for highest educational attainment, social class, ever having strabismus, and treatment for amblyopia.

‡Adjusted for sex, social class, ever having strabismus, and treatment for amblyopia.

§Ordinal regression—odds of self report of poorer health, independent of level, adjusted for highest educational attainment, marital status, home behaviour at 16 years, sex, school adjustment at 16 years, previous mental health, and change in social class in previous 10 years.

¶Adjusted for highest educational attainment, marital status, home behaviour at 16 years, sex, school adjustment at 16 years, previous mental health, and change in social class in previous 10 years.

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**Table 4** Associations between mild or moderate/severe amblyopia and behaviour, social activities, and unintended injuries during childhood

Outcome	Normal vision (No)	Amblyopia		Adjusted odds ratio (95% CI)*	P value
		Degree	No (%) affected		
Behaviour (at age 7): BSAG score, in upper decile	6987	Mild	24/234 (10)	1.20 (0.77 to 1.88)	0.419
		Moderate/severe	14/94 (15)	1.73 (0.92 to 3.23)	0.087
Sport (at 11 years): “hardly ever”	6463	Mild	24/210 (11)	1.15 (0.72 to 1.85)	0.550
		Moderate/severe	9/89 (10)	1.02 (0.47 to 2.22)	0.951
Social activities—dancing/disco (at 16 years): “hardly ever”	5778	Mild	74/216 (34)	1.32 (0.96 to 1.82)	0.086
		Moderate/severe	20/75 (27)	0.86 (0.49 to 1.53)	0.611
Unintentional injuries needing hospital care:					
Inpatient care up to age 16	6757	Mild	71/255 (28)	1.17 (0.86 to 1.59)	0.319
		Moderate/severe	19/88 (22)	0.76 (0.44 to 1.33)	0.334
Outpatient care at age 12-16	6807	Mild	60/257 (23)	0.89 (0.65 to 1.23)	0.482
		Moderate/severe	25/89 (28)	1.05 (0.62 to 1.76)	0.858

BSAG=Bristol social adjustment guides.

\*Amblyopia v normal vision, adjusted for social class, sex, ever having strabismus, and treatment for amblyopia.

poor coordination (0.3%, 0.2% to 0.4% with normal vision and 0.4%, 0% to 1.1% with amblyopia,  $P=0.403$ ), so further formal analysis was not possible.

### Health

People with amblyopia were no more likely than those with normal vision to report poor general health (table 3, table B). Equally, they were no more likely to report depression or psychological distress in adult life. Overall, 213 (2.4%) people died between 16 and 41 years, including 5 (1.2%) of those who had amblyopia. The small numbers precluded further formal analysis. Overall, people with amblyopia were no more likely than those with normal vision to have unintended injuries in childhood requiring inpatient or outpatient hospital care (table 4, table A). In adult life, amblyopia was not associated with increased odds of injuries at work. Moderate/severe (but not mild) amblyopia was associated with road traffic accidents as a driver between ages 17 and 33. An isolated association between mild amblyopia and injuries needing inpatient care occurred, but no such associations existed with either moderate/severe amblyopia or outpatient care (table 3, table B). The interpretation of this observation, as of other isolated statistically significant associations, is difficult in the context of multiple comparisons.

### Discussion

Our findings indicate that, on average, people with amblyopia can expect to do as well as their peers with normal vision in both eyes in terms of educational attainment, employment, and occupational and socioeconomic achievement. They do not seem to be disadvantaged in relation to social activities, nor are they at increased risk of behavioural difficulties or social maladjustment as children. They are no more likely to report overall worse general health or mental health, to be involved in serious unintended injuries generally, or to be at overall increased risk of death.

### Strengths and weaknesses of the study

Reliance on parental history for some information and on assessments by general medical examiners (rather than ophthalmologists) raises the possibility of misclassification of amblyopia. However, visually impairing disease is rare in childhood,<sup>12</sup> and amblyopia is the most likely cause of unilateral reduced acuity despite optical correction. Thus, most people with amblyopia were probably correctly classified, and they also probably account for most "cases." This is supported by our prevalence of 1.2% for residual amblyopia at a threshold of 6/18 or worse,

which is consistent with previous reports.<sup>13 14</sup> The 1958 birth cohort is a representative population, studied longitudinally, ensuring that visual status was known before measurement of a range of important outcomes. This confers important advantages for studying the functional consequences of amblyopia; the size of the population studied was sufficient to detect even modest associations, for key outcomes, where they exist. No directly comparable previous work in this area exists, but indirect comparisons are made below.

### Implications of findings

Extensive psychophysical and neurophysiological work has elegantly delineated clear deficits in specific components of vision, such as contrast sensitivity, that occur in amblyopia.<sup>2</sup> Our findings fail to identify their "real life" functional correlates. For example, the reading speed of people with amblyopia may be measurably slower but may nevertheless, on average, be adequate for educational or occupational purposes. Experimental work will remain the foundation for advancing understanding of visual development and the pathophysiology of amblyopia, but its value to decisions about screening needs to be enhanced by considering the impact of specific visual abnormalities on everyday activities, as well as the degree to which these are permanently reversed by treatment.

Screening for amblyopia became established in an era when the benefits and harms of interventions were often less rigorously scrutinised than now; the two major justifications were statutory occupational preclusion and the risk of visual impairment if the affected person lost vision in their normal eye. We recently showed that in the UK the lifetime risk to people with amblyopia of visual impairment or blindness through disease or injury to their normal eye is between 1% and 3%.<sup>15</sup> This risk, and the attendant consequences such as permanent loss of paid employment, are more common than previously thought and now seem to be consistent across populations.<sup>16</sup> Although important, this event is, nevertheless, likely to be too rare at a whole population level (affecting 4.8-14.4/10 000 of the whole population<sup>15</sup>) to alone be sufficient justification for screening for all levels of amblyopia, especially in the current climate of competition for finite health care resources. A stronger case can be made for screening for moderate and severe amblyopia—using, for example, the minimum visual standards for driving as the threshold for acuity in the amblyopic eye—to identify people who would have predictable and measurable adverse outcomes should they lose the use of their non-amblyopic eye. This argument is supported by recent UK data from a randomised



trial of the outcomes of preschool vision screening for and treatment of unilateral visual loss.<sup>17</sup>

The limited literature to date on the general employment and specific occupational limitations associated with amblyopia, and their implications for socioeconomic advancement, suggests that it has little impact on occupational class.<sup>16</sup> Our findings strengthen this view. The proportion of the population working in the “target” occupations to which acuity restrictions apply in the UK is not high (7.6%), so less than 4/1000 people overall (that is, those with amblyopia) would face potential occupational preclusion. Notably, we found no evidence for differential impact of occupational preclusion by social class, and injuries in the workplace were no more common among people with amblyopia. Importantly, to justify screening for amblyopia as a means of obviating potential occupational preclusion, certainty would be needed that good improvements in acuity (and for some occupations normal vision) can be achieved with treatment in childhood and that these are sustained throughout adult life in all cases. Current data suggest that such improvement is neither universal nor accurately predictable.<sup>18–20</sup> Opportunities for future population based work on long term outcomes may arise in the context of existing birth cohort studies,<sup>21</sup> as well as other longitudinal studies and clinical treatment trials. Finally, we urge ophthalmic professionals to engage in work delineating the safety risks associated with amblyopia, so that affected people are advised more informatively and occupational preclusions are more firmly evidence based.

We recognise that our study does not examine the qualitative impact of amblyopia at the level of the individual. Previous work in this area has mainly examined the impact of treatment (occlusion or glasses) or associated manifest strabismus, rather than of amblyopia itself.<sup>22–24</sup> Information about the impact on quality of life of unilateral visual loss acquired through disease or injury in adult life cannot be extrapolated to amblyopia. Methodologically robust research, ideally combining qualitative and quantitative approaches and based on representative population samples, would be of value in characterising the nature and degree of limitation to everyday life of people with amblyopia, and whether, and how, this is related to severity of amblyopia. This could be complemented by information obtained through routine assessment of vision related quality of life in a clinical setting, as well as in specific research studies, including treatment trials, on amblyopia. Elaboration of the nature and severity of the disability conferred by amblyopia, and the extent to which it is improved by treatment, is essential to further characterising its public health importance, which remains uncertain.

## Conclusions

We suggest that the need is greater than ever before for concerted research on what it means to be amblyopic and, importantly, how this varies with severity of amblyopia and how it changes with treatment, so that screening programmes can be designed to best serve those people who have the most to gain from the earliest possible identification.

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## What is already known on this topic

Amblyopia is the most common disorder seen in paediatric ophthalmic practice in industrialised countries

Debate about the value of established whole population screening partly reflects the paucity of evidence of the functional consequences of amblyopia and their impact at a population level

## What this study adds

Distinguishing, at a population level, between the lives of people with amblyopia and those without in terms of important educational, health, and social outcomes may be difficult

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