ORIGINAL ARTICLE

Effect of meningitis in infancy on school-leaving examination results

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Objectives: To determine whether having had meningitis in infancy adversely affects academic achievement at age 16.

Methods: A case-control study in England and Wales of 461 teenagers who had bacterial meningitis in infancy and 289 GP matched controls recruited when the index cases were aged 5. Outcome measures: Comparison between index cases and controls of the type of school attended; the number of GCSE examinations attempted; the number of examinations passed (grades A*–C) and achievement in five key subjects. Assessment of examination results according to the age at which meningitis occurred. The effect of meningitis-associated disability on GCSE results.

Results: 36/461 (7.8%) index cases compared with none of the controls were in special schools. Significantly more index cases (117/461 (25.4%)) than controls (19/289 (6.6%)) did not pass any GCSE examinations. Significantly more index cases (184/385 (47.8%)) than controls (59/232 (25.4%)) attending comprehensive schools failed to achieve the national educational standard of five passes at grade C. Pupils attending comprehensive schools who did not have meningitis-associated disability also passed significantly fewer GCSE examinations than the controls. The age at which meningitis had occurred was not associated with subsequent academic achievement.

Conclusions: After meningitis in infancy a quarter of survivors failed to pass any GCSE examinations; nearly half of those attending state schools did not attain the national educational standard. "Healthy" survivors of bacterial meningitis in infancy pass significantly fewer GCSE examinations than the controls. All cases of bacterial meningitis in infancy should have a full postinfection assessment and continuing supervision.

As far as we know, this is the first published report on the educational achievements of a large group of teenagers who had meningitis during the first year of life and the only one that relates to a national cohort. The subjects of this study are the survivors from a national incidence study of meningitis in infancy carried out in England and Wales in 1985–7.¹ The prevalence of meningitis-associated disability was assessed among the surviving children when they were 5 years old and compared with general practitioner controls matched for age and sex.² Behavioural differences between the index cases and the same controls were assessed when the children were 13 years old.³ This study compares the General Certificate of Secondary Education (GCSE) results at 16 years of age of 739 index cases who had confirmed bacterial meningitis in infancy and 480 of the matched controls who participated in the previous studies.^{2 3}

METHODS

The subjects of this study were 739 16 year olds who had had bacterial meningitis in infancy and who had participated in follow-up studies when they were aged 5 and 13, and 480 general practitioner controls matched for age and sex who had been recruited for the five-year follow up study and had participated in the behavioural study when they were 13 years old. The age/sex matched controls came from the same general practitioner lists as the index cases. They were identified by the local family health services authority, in order to avoid bias. The only other requirement of the controls was that they should not have had meningitis.

The 16 year olds were asked, through their parents, about the type of school they attended and whether they had, at any time, been "statemented" (see box 1). Pupils were asked to list all the

GCSE examinations they had taken; the number passed and the grades obtained. This information was collected by a standard questionnaire. No additional information was sought.

The GCSE is the examination system used in England and Wales to assess pupils at the end of their secondary education at age 16. The examination passes are graded A* to E, and the national yardstick is a pass in five subjects at grade C or above.

Data analysis

As with our previous study³ the data were handled and analysed using EpiInfo (version 6) (Center for Disease Control and Prevention, Atlanta, USA). The information was analysed according to the type of school attended; the number of GCSE examinations taken; the number passed and the grades obtained (A*–C only). Passes in five key subjects (English language, English literature, mathematics, science and a modern foreign language) were analysed separately. Each of these subjects was scored (grade A* pass = 6 points, grade A pass = 5 points....grade E pass = 1 point) and the total number of points gained by each pupil was recorded. Five passes at grade C equated to 15 points. Pupils of higher academic ability who passed

Box 1: "Statemented"

In England and Wales, children with special educational needs are assessed by a multiprofessional group of examiners. Qualifying children are issued with "A Statement of Special Educational Needs". This is known as being "Statemented". Local education authorities are required by law to make special educational provision for such children.

Table 1 Types of school attended by index cases and controls

School type	Index cases No (%)	Controls No (%)
Comprehensive	385 (83.5)	232 (80.3)
Grammar	14 (3.0)	24 (8.3)
Independent	25 (5.4)	32 (11.1)
Special	36 (7.8)	0
Other	1	1
Total	461	289

more than five “key” subjects—for example, passes in two science subjects, achieved correspondingly higher scores. In addition, index cases were compared according to whether they had had meningitis as neonates (<29 days after birth) or as infants (aged 1–12 months).

The effect of meningitis-associated disability, which had been determined when the index cases were 5 years old, on GCSE results was recorded also.

Statistical methodology

Both continuous and categorised analyses were performed to assess the differences between index cases and controls. Most pupils attended comprehensive schools and most of the analyses relate to this group. The number of pupils attending other types of school was too small for detailed analysis. Continuous variables were categorised and the distributions of index cases and controls in each category compared using χ^2 tests. For binary variables, odds ratios (ORs) and 95% confidence intervals (CIs) were determined for index cases versus controls.

Research ethics considerations

Before the study the Central Office for Research Ethics Committees (COREC) was approached to determine whether formal ethics approval by the Multicentre Research Ethics Committee was required. Having examined the study protocol and questionnaire, COREC concluded that the acquisition of GCSE results in a group of children (and families) who were already well known to the researchers presented no material ethical problems and that such data collection fell outside the remit of ethics committees as it was not NHS or health related data as defined in the Governance Arrangements for Ethics Committees (GAFREC) para 3.1.

RESULTS

Completed questionnaires were received from 461/677 (68%) index cases and from 289/432 (67%) controls. Sixty-two of the 739 index cases and 48 of the 480 controls from the behaviour study³ had moved house and could not be traced. The sex distribution (M:F) for index cases (1:1.2) and controls (1:1.1) was similar and not significantly different from that in the previous study.³ The proportion of the index cases with severe/moderate disability, assessed when they were 5 years old (16.5%), was similar to that among index cases in this study (15.0%). Table 1 shows the proportions of index cases and controls attending various types of school. This compares with England as a whole where 83% of secondary school pupils preparing for their GCSE examinations attend state comprehensive schools.⁴ Thirty-six index cases (7.8%) and no controls attended special schools, compared with 1.7% of the general school population in England.⁴ Eighty per cent (29/36) of 16 year olds in special schools had had severe/moderate disability when assessed at age 5. Eight (22%) special school pupils had been infected with *Escherichia coli* or another “coliform” bacterium and 11 (31%) had had meningitis due to *Haemophilus influenzae*. There was no association between the age at which meningitis had occurred and attendance at a special school.

During their secondary education 56 (12.1%) index cases, including all those in special schools, and 10 (3.5%) controls had been identified as children with special educational needs (“Statemented”; box 1) ($\chi^2 = 16.7$; $p < 0.0001$; OR = 3.9; 95% CI 1.9 to 7.7). Among “Statemented” children in mainstream education 18/20 index cases and 7/10 controls attended comprehensive schools.

Index cases attending comprehensive schools were twice as likely as controls to sit fewer than five GCSE examinations: 9.4% compared with 4.7% (table 2) ($p = 0.04$; OR = 2.1; 95% CI 1.0 to 4.2). Analysis of the continuous variables showed a highly significant difference in the mean number of examinations taken by index cases (mean (SD) 8.43 (3.5); $n = 385$) and controls (mean (SD) 9.20 (2.1); $n = 232$) ($p = 0.0002$) (t test).

When pupils from all schools are considered, more index cases (117/461 (25.4%)) than controls (19/289 (6.6%)) failed to gain any GCSE passes at grade C or above ($\chi^2 = 42.3$; $p < 0.0001$; OR = 4.8; 95% CI 2.9 to 8.0). The proportion of index cases attending comprehensive schools who failed to achieve five passes at grade C or above (184/385 (47.8%)) is significantly higher than that for controls (59/232 (25.4%)) (table 3; $p < 0.0001$; OR = 2.7; 95% CI 1.9 to 3.8). Analysis of the continuous variables for the mean number of subjects passed by index cases (mean (SD) 5.05 (4.1); $n = 385$) and controls (mean (SD) 6.88 (3.5); $n = 232$) is highly significant ($p < 0.0001$; t test).

Table 2 Number of GCSE subjects taken by index cases and controls attending schools of different types

School type	Pupil group (No of pupils)	Number of GCSE examinations taken				Mean (SD)
		0†	1–4†	5–10†	>10†	
Comprehensive	Index (385)	24 (6.2)	12 (3.2)	285 (74.0)	64 (16.6)	8.43 (3.5)*
	Control (232)	5 (2.2)	6 (2.5)	176 (76.0)	45 (19.3)	9.20 (2.1)
Grammar	Index (14)	1 (7.1)	0	9 (64.4)	4 (28.5)	9.21 (3.0) †
	Control (24)	0	0	13 (54.2)	11 (45.8)	10.33 (1.0)
Independent	Index (25)	0	0	21 (84.0)	4 (16.0)	9.28 (1.4) †
	Control (32)	0	0	25 (78.1)	7 (21.9)	9.62 (1.1)
Special	Index (36)	26 (72.1)	6 (16.7)	4 (11.2)	0	–
	Control (0)	–	–	–	–	–

*Significant difference in means: $p = 0.0002$ (t test); †difference in means not significant; ‡results are shown as No (%) of pupils.

Table 3 Number of GCSE passes (grade A*-C) for index cases and controls according to the type of school attended

School type	Pupil group	Number of passes (A*-C)				Mean (SD)
		0‡	1-4‡	5-10‡	>10‡	
Comprehensive	Index (385)	86 (22.3)	98 (25.5)	168 (43.7)	33 (8.5)	5.05 (4.1)*
	Control (232)	19 (8.2)	40 (17.2)	149 (64.2)	24 (10.4)	6.88 (3.5)
Grammar	Index (14)	2 (14.3)	1 (7.1)	8 (57.2)	3 (21.4)	8.00 (3.9) †
	Control (24)	0	1 (4.2)	13 (54.2)	10 (41.6)	9.79 (1.7)
Independent	Index (25)	0	1 (4.0)	20 (80.0)	4 (16.0)	9.04 (1.8) †
	Control (32)	0	0	27 (84.4)	5 (15.6)	9.34 (1.3)
Special	Index (36)	29 (80.5)	5 (14.0)	2 (5.5)	0	
	Control (0)	—	—	—	—	

*Significant difference in means: $p < 0.0001$ († test); † difference in means: not significant; ‡ results are shown as No (%) of pupils.

Index cases attending comprehensive schools who had shown no signs of meningitis-associated disability at age 5 were equally unsuccessful at achieving the national standard of five passes at grade C: index cases 170/348 (48.9%) compared with 59/232 (25.4%) controls ($p < 0.0001$; OR = 2.8; 95% CI 1.95 to 4.02). Analysis of the continuous variable for the mean number of passes is also significant; healthy index cases: mean (SD) 4.99 (4.11); controls: mean (SD) 6.88 (3.52); 95% CI 1.25 to 2.54; $p < 0.0001$. Among pupils attending comprehensive schools who sat no GCSE examinations a "Statement of Special Educational Need" had been issued to 3/5 (60%) controls but to only 5/24 (21%) index cases.

The results for the five "key" subjects show a similar pattern among comprehensive school pupils, with 219/385 (56.9%) index cases compared with 81/232 (34.9%) controls failing to gaining the equivalent of five grade C passes (15 points) ($\chi^2 = 28.0$; $p < 0.0001$; OR = 0.4; 95% CI 0.3 to 4.0) (table 4). English language and mathematics were failed by 209/385 (54.3%) of all index cases compared with 78/232 (33.6%) of all controls ($\chi^2 = 24.5$; $p < 0.0001$; OR = 0.4; 95% CI 0.3 to 0.6).

There were no significant differences in educational achievement between pupils who had meningitis as neonates and those infected in months 2-12 of life for the number of examinations taken, the number passed at grade C or above or success in the five key subjects.

DISCUSSION

As far as we know, this is the largest study into the effects of meningitis in infancy on educational achievement at age 16, and the only one based on a national cohort. It demonstrates

for the first time the full extent of learning disability among survivors, even those who had previously appeared to be unscathed. Although other workers²⁻⁶ have reported learning problems after meningitis in small babies, this is the first time that these problems have been assessed against a national examination system for 16 year olds. At the extreme end 36 (7.8%) index cases were in special schools, more than four times the national average for England, compared with none of the controls. More than a fifth of index cases attending comprehensive schools failed to pass even one GCSE at grade C, compared with 8.2% of the controls and 3.7% of pupils in England. The reasons for the differences between the controls and the school population of England are not clear but they do not alter the conclusion that more than a quarter of children who had meningitis in infancy have major educational problems, either because they are in special schools or because they were unable to pass even one GCSE examination.

It is worrying that among index cases attending comprehensive schools who did not even attempt one GCSE examination, only 5/24 (21%) had been "Statemented", compared with 3/5 (60%) controls. Although the numbers are small this suggests that the needs of children who had meningitis in infancy are not being met.

It is alarming that children who appeared to have escaped meningitis unscathed when assessed at age 5 did no better in their GCSE examinations than those with recognised disabilities. This emphasises the need not only for a full postinfection medical assessment but also for continuing educational support throughout the school years. The results of this study show that this support is not at present being given.

Table 4 GCSE point score in five key subjects according to the type of school attended

School type	Pupil group	Number of GCSE points				Mean (SD)
		0*	1-14*	15-24*	>24*	
Comprehensive	Index (385)	38 (9.9)	181 (47.0)	116 (30.1)	50 (13.0)	13.47 (9.1)
	Control (232)	10 (4.3)	71 (30.6)	106 (45.7)	45 (19.4)	17.45 (8.3)
Grammar	Index (14)	1 (7.1)	1 (7.1)	4 (28.7)	8 (57.1)	23.71 (10.5)
	Control (24)	0	2 (8.4)	7 (29.9)	15 (61.7)	26.83 (7.3)
Independent	Index (25)	0	1 (4.0)	9 (36.0)	15 (60.0)	27.44 (8.5)
	Control (32)	0	2 (6.2)	10 (31.4)	20 (62.4)	27.59 (8.7)
Special	Index (36)	28 (77.8)	7 (19.4)	1 (2.8)	0	
	Control (0)	—	—	—	—	

Differences in means: not significant.

*Results are shown as No (%) of pupils.

What is already known on this topic

- Nothing is known about the total burden that meningitis in infancy has on educational achievement of teenagers.
- A few previous studies have alluded to educational problems or reduced IQ among children who had meningitis in infancy, but these relate to small selected patient groups and not to a national cohort.

What this study adds

This study is the first report on the academic achievement of a national cohort of cases of bacterial meningitis in infancy followed up to the age of 16. It has identified that:

- A quarter of index cases did not pass any GCSE examinations at grade C.
- Twice as many index cases as controls attending comprehensive schools failed to achieve the national standard of five GCSE passes at grade C.
- Index cases who had previously appeared to be unscathed by meningitis did no better than those with meningitis-associated disability that was recognised when they were 5 years old.

Since the national incidence study in England and Wales in 1985–7¹ there have been substantial improvements in the management and treatment of meningitis in infancy. Between 1985–7 and a second national incidence study carried out in 1996–7 the acute phase mortality rate from neonatal meningitis fell from 25.5% to 6.6%⁷; however, there was little difference in the rates of moderate/severe disability between the two cohorts when tested at 5 years of age.⁸ It remains to be seen whether the improvements in care of babies with meningitis will be reflected in their end of school examination results at age 16. Almost a third of the 16 year olds who attended special schools had had meningitis due to *H influenzae*. The virtual eradication of *H influenzae* as a cause of infantile meningitis, after the

introduction of the HIB vaccine, should in itself improve the overall outcome of infantile meningitis. Raising parental awareness of the long term consequences of meningitis in infancy might also improve the uptake of immunisation.

The adverse consequences of infantile meningitis reported when our study group was 5,² and 13 years old³ clearly extend into adult life and seriously affect educational achievement. It is essential that all cases of bacterial meningitis occurring during the first year of life are followed up fully so that children who require educational and other support are recognised at an early age.

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