Behaviour and cognitive outcomes from middle ear disease

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Abstract

***Objectives*—To resolve controversies over associations between a history of middle ear disease and psychosocial or cognitive/ educational outcomes**

***Design*—Multipurpose longitudinal birth cohort study. Original cohort comprised all UK births between 5 and 11 April 1970; data were available for approximately 12 000 children at 5 years old and 9000 children at 10 years old.**

***Methods*—For 5 year old children, parent reported data were available on health, social, and behavioural factors, including data on two validated markers of middle ear disease. Cognitive tests were administered at 5 and 10 years of age, and behavioural problems rated at 10 years by the child's teacher.**

***Results*—After adjustment for social background and maternal malaise, the developmental sequelae of middle ear disease remained significant even at 10 years. The largest effects were observed in behaviour problems and language test data at age 5, but effect sizes were modest overall.**

***Implications*—These results provide an epidemiological basis for policies that aim to minimise the sequelae of middle ear disease by awareness in parents and preschool teachers, early referral, and intervention for more serious or persistent cases.**

(*Arch Dis Child* 1999;**80**:28–35)

Keywords: middle ear disease; behaviour problems; cognitive development; longitudinal study

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Accepted 18 August 1998

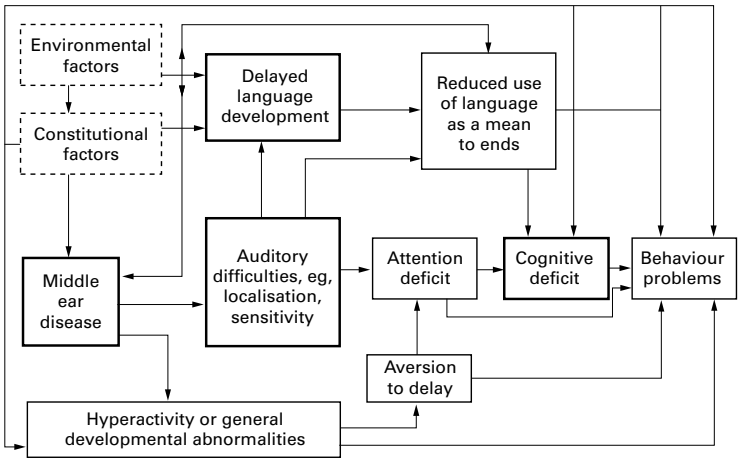

Figure 1 Schema illustrating some possible relations between middle ear disease, illness, hearing, communication, and developmental sequelae.

Otitis media with effusion (OME) or "glue ear" is the most common cause of hearing loss in children; this fluctuating condition can persist in some children, leading to detrimental effects on behaviour and development. Antisocial behaviour or inattentiveness are consequent on the child's inability to hear, leading to frustration, apparent disobedience, and less use of language as a means to ends. Deficits in speech, language, and behaviour, particularly in children with early onset OME, may lead to reduced cognitive ability.[1]

The balance of existing evidence suggests that in most affected children the developmental and behavioural sequelae of otitis media are short lived and relatively mild.[2] Psychosocial and educational outcomes have received less attention than measures of language. Clinical and epidemiological studies suggest some association, but the effect appears small, and the variability wide, probably because of confounding factors that differ between various small samples.[3]

There are advantages in using large longitudinal cohorts to document developmental influences, particularly where these are likely to be complex or to change over time. The prospective stratification (that is, on the middle ear disease variable) which cohort studies permit, greatly reduces the major selection biases present in clinically based studies, such as comorbidity or the tendency to seek care, which may exaggerate the true effects. Most otitis media sequelae studies have lacked sufficient numbers and their designs have not permitted control for factors such as socioeconomic status and maternal depression (or malaise), which are known to be associated with behavioural development or delayed cognition in children.[4] Studies need to take into account the complex set of developmental influences suggested in fig 1.

We have analysed the 1970 British birth cohort (BCS70), a multipurpose longitudinal study, designed to investigate educational, physical, and social development.[5] It is about 10 times larger than any of the other cohorts from Dunedin,[6] Nijmegen,[7] and Boston[8] that have considered behavioural and developmental sequelae of OME. Although these cohort studies provide some of the best evidence of OME sequelae, the numbers of affected children in the Nijmegen and Dunedin studies were small, and the Boston study excluded non-white children and underestimated the occurrence of OME in the children who were tested less frequently.

In our analyses, we emphasise the data on 10 year behaviour assessments, to provide

statistical evidence for the more contentious longer term effects of middle ear disease.

Methods

GENERAL METHODOLOGICAL CONSIDERATIONS

Limitations of cohort data

In BCS70, the available markers of the independent variable of middle ear disease are relatively crude: parental reports of suspected/confirmed hearing problems and purulent (non-wax) ear discharge. However, objective measurements repeated over a long period are very expensive, making infeasible any study combining objective markers and the large sample size required for generality, statistical control, and tests of interaction. The total cumulative histories of middle ear disease during childhood, rather than the condition of an ear on a particular day, are what determine sequelae, and are relevant—for example, in deciding whether a child with persistent problems would warrant surgical intervention.

The index group definition is likely to give a conservative estimate of actual disease because the control group will contain some affected children with mild/short term conditions underreported by parents.[9]

Control for confounders

Some of the inherent biases in report can be controlled out. For behavioural and cognitive signs (as distinct from evident problems and symptoms), parental report is likely to be undersensitive. A parent of more advantaged socioeconomic status will be particularly aware and therefore report more hearing problems, but might also have a child with better, not worse, scores on a language scale. This will make the analysis of associations conservative with respect to type I errors on performance measures. For power this is offset by the large number of children for whom complete data are available for analysis. Previous univariate analyses of the 1970 birth cohort[5] have shown that boys are more likely than girls to have reported problems of ear discharge and hearing and, that boys more often exhibit behaviour problems than girls. Our analyses are therefore adjusted for sex as well as socioeconomic status.

SUBJECTS

The original cohort consisted of all births in the UK between 5 and 11 April 1970, with available data on > 12 000 children and additional sweeps at 5, 10, 16, and 21 years.[5] For the analyses that follow, complete data were available on ~ 12 000 children at 5 years of age and ~ 9000 children at 10 years. Owing to mobility, not all the children were traceable, although this did not significantly affect the proportions that had middle ear disease.

INDEPENDENT VARIABLES

At age 5, markers of middle ear disease were reported by parents, in the form of whether or not the child had "suspected hearing difficulty" or "purulent (non-wax) ear discharge" up to the age of 4 as well as between ages 4 and 5. There was little difference in rates of ear problems between these periods, so the data were combined to derive categories "ever" or "never" for each of the reported ear/hearing problem variables up to age 5.

For our analyses, independent variables were the reported ear discharge or hearing difficulty; covariates were maternal malaise, sex, and socioeconomic status. These were the most relevant, although not the only covariates that could have been considered—for example, in this analysis we have not controlled for the child's general health. The socioeconomic status item is a seven value variable (also known as the social index,[10] representing advantaged and disadvantaged children at the extremes) based on a combination of eight items, including fathers' occupation, highest known qualification of either parent, type of accommodation, and neighbourhood. For simplicity of representation, a three valued variable is used grouping the levels of the original seven point social index (one and two; three, four, and five; six and seven).

A maternal malaise score at 5 and 10 years of age was calculated from the sum of items in a 24 item malaise inventory completed by the mother of the cohort member, including items on depression, neuroticism, and feeling miserable. This scale was found previously to discriminate well between those with and without psychiatric disorder.[11]

BEHAVIOUR PROBLEMS

At 5 and 10 years of age, maternally reported behaviour problem data were collected using Rutter A rating scales[11]; at 10 years of age, teacher reported behaviour was collected using a 52 item scale combining items from the Rutter B scale and the Connors teacher rating scale.[12] No teacher behaviour ratings were available at 5 years.

Factor analysis of the maternally reported behaviour problem scale produced two first order subscales at age 5: antisocial and neurotic behaviour.[13] To allow for the possibility that otitis media affects specific aspects of behaviour, antisocial behaviour was broken down into two second order factors: (1) hyperactive behaviour with items including the child not concentrating, teasing other children, and being excitable, impulsive, restless, overactive, and easily distracted; and (2) behaviour associated with "poor conduct", characterised as destroying belongings, frequently fighting, taking things belonging to others, etc. This division might provide further insight into the specific types of behaviours associated with middle ear disease.

Similar subscales for maternal and teacher reported behaviour at age 10 were derived using factor analysis; these included antisocial and neurotic behaviour and clumsiness.[12] In addition, ratings of inattentiveness were recorded in the teacher scale and hyperactive behaviour in the maternal scale. Speech articulation was reported in an additional questionnaire covering the educational and social environment of the study child, as seen by the class teacher and school head.

Table 1 Prevalence (%) of behaviour problems at 5 years of age in relation to ear discharge, hearing difficulty, sex, and socioeconomic status

	Extreme antisocial behaviour (n)	*Extreme neurotic behaviour (n)*	*Hyperactivity (n)*	*Poor conduct (n)*
Ear discharge up to age 5				
Never	9.4 (1051)	9.5 (1055)	9.9 (1098)	9.6 (1066)
Ever	13.1 (190)	13.0 (188)	13.6 (196)	12.6 (182)
Hearing difficulty up to age 5				
Never	9.6 (1107)	9.6 (1107)	9.9 (1137)	9.7 (1115)
Ever	13.0 (137)	13.9 (147)	14.4 (151)	12.8 (135)
Sex				
Male	13.0 (883)	8.9 (605)	11.3 (765)	13.0 (883)
Female	6.7 (423)	11.1 (701)	9.4 (589)	6.7 (426)
Socioeconomic status of household				
1 (most advantaged)	4.0 (109)	9.2 (251)	6.5 (178)	5.3 (144)
2 (average)	8.9 (616)	9.4 (646)	9.7 (664)	8.9 (616)
3 (most disadvantaged)	16.6 (580)	11.6 (406)	14.8 (512)	15.8 (549)

All comparisons are significant, $p < 0.01$.

COGNITIVE TEST DATA

Verbal performance tests at 5 years included the English picture vocabulary test (EPVT), similar to the American Peabody picture vocabulary test, which is a test of passive vocabulary. Non-verbal tests at 5 years included human figure drawing (a modified version of the "draw a man" test measuring conceptual maturity) and the copy design test (CDT). In the CDT, children were asked to make two copies of each of eight designs, which were later judged blind on shape, symmetry, neatness, etc.

Verbal tests at 10 included a picture language score (similar to EPVT) and the verbal IQ British ability scales (BAS). Verbal BAS includes the three subtests: word definitions, recall of digits, and similarities, similar to those in the American differential ability scales (DAS). The non-verbal BAS measured at 10 years included the matrices test.

ANALYSES

On the continuous and normally distributed dependent measures (behaviour and cognitive tests) all effects were examined initially using analysis of covariance. In addition, for the behavioural scores only, binary variables were derived by defining a cut off at the 90th centile of the distribution to test the operative range of associations. A score falling beyond this extreme suggests a level of gross behaviour problems justifying concern. Overall, the two types of analysis gave similar patterns of results for the behaviour scores. Logistic regression analysis was used to examine the relation between the covariates and these binary behavioural variables. The ear discharge and hearing difficulty responses were considered separately as independent variables.

Adjusted odds ratios (OR) and 95% confidence intervals (CI) for behaviour problems in relation to middle ear disease were computed using logistic regression, controlling for sex, socioeconomic status, and maternal malaise at 5 years. An OR > 1 indicates that behaviour problems are more likely in the middle ear disease compared with the control group and an OR < 1 indicates that behavioural problems are less likely.

Results

The prevalences of middle ear disease in BCS70 are: 11.5% for ear discharge (probably reflecting the poorly treated extreme of acute otitis media in the 1970s) and 8.4% for hearing difficulty (probably reflecting cumulative OME severity and persistence of effusion), conforming to that found in objectively established epidemiological data.[14] In addition, we have shown highly significant mutual associations between the two markers and with the known otitis media risk factors (such as parental smoking and attendance at day care), consistent with the epidemiological literature.[15]

CONTRASTS AT 5 YEARS OF AGE

For the 5 year data, preliminary univariate analyses (raw relative risks) for the ear discharge and hearing difficulty variables with individual behaviour items have been reported elsewhere,[5] but prevalence figures for behaviour scores are given in table 1. To enhance reliability and generalisation, subscales from factor analysis are used here. We have reported elsewhere[16] preliminary main effect associations at age 5, for mean behaviour (antisocial and neurotic) scores only. For interpretation as sequelae, greater multivariate statistical control is presented here. All associations reported are in the direction of greater deficit or abnormality for the marker value reflecting a middle ear disease history.

Table 2 gives the mean magnitude (in SD units) of effects of ear discharge and hearing difficulty on the behaviours reported at 5 years. Overall, the effects of the adjustments made were mostly quite small. Taking the overall mean, the largest magnitude effects at 5 years are seen in the neurotic and hyperactive behaviours. Irrespective of middle ear disease, the prevalence of reported behavioural problems is higher in children with a more disadvantaged socioeconomic status (table 1), thus confirming the requirement for control of socioeconomic status.

Table 2 Unadjusted and adjusted magnitude of effects of hearing difficulty and ear discharge on the continuous behaviour scores at 5 years of age

Middle ear disease marker	*Antisocial*	*Neurotic*	*Hyperactive*	*Poor conduct*
Unadjusted magnitudes				
Hearing difficulty	0.13	0.22	0.19	0.08
Ear discharge	0.15	0.20	0.13	0.14
Adjusted* magnitudes and 95% CI				
Hearing difficulty	0.12 (0.06 to 0.18)	0.20 (0.14 to 0.25)	0.19 (0.12 to 0.25)	0.07 (0.01 to 0.13)
Ear discharge	0.08 (0.03 to 0.13)	0.14 (0.09 to 0.19)	0.07 (0.02 to 0.13)	0.07 (0.02 to 0.12)

Results are reported in SD units and are for parent reported behaviour (Rutter A scale).
*Adjusted for socioeconomic status, sex, and maternal malaise (n = 12 554).

Table 3 Unadjusted and adjusted odds ratio of dichotomous behaviour scores at 5 years of age as a function of ear discharge

Socioeconomic status (grouped)	*Antisocial*	*Neurotic*	*Hyperactivity*	*Poor conduct*
Unadjusted odds ratio				
1 (most advantaged)	2.01	1.46	1.24	1.55
2 (average)	1.27	1.41	1.41	1.21
3 (most disadvantaged)	1.49	1.40	1.48	1.41
Overall (95% CI)	1.45 (1.21 to 1.64)	1.43 (1.20 to 1.69)	1.42 (1.21 to 1.68)	1.35 (1.14 to 1.60)
Adjusted* odds ratio and 95% CI				
1 (most advantaged)	1.70 (1.03 to 2.78)	1.27 (0.86 to 1.87)	1.10 (0.70 to 1.74)	1.35 (0.85 to 2.15)
2 (average)	1.14 (0.87 to 1.48)	1.29 (1.01 to 1.66)	1.31 (1.03 to 1.68)	1.09 (0.84 to 1.43)
3 (most disadvantaged)	1.33 (1.02 to 1.74)	1.21 (0.89 to 1.65)	1.35 (1.03 to 1.77)	1.26 (0.96 to 1.65)
Overall†	1.27 (1.07 to 1.52)	1.27 (1.07 to 1.51)	1.29 (1.09 to 1.52)	1.19 (1.0 to 1.42)
p value for ear discharge	0.008	0.007	0.003	0.054

Results are for parent reported behaviour—defined at 90th centile of distribution of continuous scores.
*Adjusted for sex and maternal malaise. †Overall odds ratio (combining all socioeconomic status groups) adjusted for sex, socioeconomic status, and maternal malaise (n = 12 497).

Ear discharge

Antisocial, neurotic, and hyperactive behaviour dichotomised at the 90th centile were significantly associated with having had ear discharge, but behaviour associated with poor conduct was not. The overall ORs (table 3) were fairly uniform across the types of behaviour; antisocial behaviour shows some social trend, but this was not significant.

The verbal test (standardised EPVT), nonverbal test, copy design, and the human figure drawing test showed no significant effects of having had ear discharge.

Hearing difficulty

Antisocial, neurotic, hyperactive behaviour, and poor conduct behaviours were significantly associated with having had hearing difficulty (table 4). These effects were larger than those for ear discharge, with an increased odds of extreme problems (beyond the 90th centile) of about 50% in those having hearing difficulty (adjusted overall OR, 1.44 for antisocial and 1.52 for neurotic behaviour). A marginally significant interaction (p = 0.06) was found for hyperactive behaviour representing synergy of hearing difficulty with maternal malaise; those children having both hearing difficulty and mothers with high malaise scores scored higher. This provides some evidence of synergistic relations between middle ear disease and other aspects of the environment in producing outcomes, giving clues to possible mechanisms.[17] The verbal test (standardised EPVT) was significantly affected by reported hearing difficulty at 5 years ($p < 0.05$; effect size, 0.17 SD), after adjustments for socioeconomic status and maternal malaise, but no significant interactions were found. The nonverbal test, human figure drawing, showed a small but significant effect of having had hearing difficulty (p = 0.01; effect size, 0.12 SD), but no significant interactions. The copy design test showed no significant effect of having had hearing difficulty.

CONTRASTS AT 10 YEARS OF AGE

Tables 5 and 6 show the mean magnitude (in SD units) of effect and 95% CI of ear discharge and hearing difficulty on the parent and teacher reported behaviours at 10 years.

Other results from the 10 year behaviour data from both parent and teacher are summarised in tables 7–10 as ORs (with 95% CI) for

Table 4 Unadjusted and adjusted odds ratio of dichotomous behaviour scores at 5 years of age as a function of reported hearing difficult*

Socioeconomic status (grouped)	*Antisocial*	*Neurotic*	*Hyperactivity*	*Poor conduct*
Unadjusted odds ratio				
1 (most advantaged)	1.56	1.92	1.30	1.61
2 (average)	1.65	1.45	1.69	1.49
3 (most disadvantaged)	1.44	1.44	1.75	1.40
Overall (95% CI)	1.41 (1.20 to 1.70)	1.53 (1.27 to 1.80)	1.53 (1.27 to 1.84)	1.37 (1.13 to 1.66)
Adjusted* odds ratio and 95% CI				
1 (most advantaged)	1.55 (0.90 to 2.66)	2.05 (1.42 to 2.94)	1.29 (0.81 to 2.04)	1.61 (1.01 to 2.58)
2 (average)	1.26 (1.17 to 2.03)	1.36 (1.04 to 1.82)	1.61 (1.25 to 2.12)	1.40 (1.06 to 1.86)
3 (most disadvantaged)	1.25 (0.88 to 1.76)	1.36 (0.92 to 2.02)	1.62 (1.16 to 2.28)	1.23 (0.87 to 1.75)
Overall†	1.44 (1.18 to 1.76)	1.52 (1.26 to 1.85)	1.56 (1.29 to 1.89)	1.37 (1.12 to 1.67)
p value for hearing difficulty	0.001	0.000	0.000	0.003

Results are parent reported behaviour—defined at 90th centile of distribution of continuous scores.
*Adjusted for sex and maternal malaise. †Overall odds ratio (combining all socioeconomic status groups) adjusted for sex, socioeconomic status, and maternal malaise (n = 12 534).

Table 5 Effects of hearing difficulty and ear discharge on the continuous behaviour scores at 10 years of age—parent reported behaviour (Rutter A scale)

Middle ear disease marker	*Antisocial*	*Neurotic*	*Inattentive*	*Clumsy*
Unadjusted magnitudes				
Hearing difficulty	−0.05	0.15	0.23	0.07
Ear discharge	0.11	0.14	0.12	0.01
Adjusted* magnitudes and 95% CI				
Hearing difficulty	−0.01 (−0.07 to 0.06)	0.15 (0.08 to 0.22)	0.25 (0.18 to 0.32)	0.07 (0.004 to 0.14)
Ear discharge	0.10 (0.05 to 0.162)	0.14 (0.07 to 0.20)	0.11 (0.05 to 0.17)	0.01 (−0.04 to 0.07)

Results are in SD units.
*Adjusted for socioeconomic status only (n = 10 867).

Table 6 Effects of hearing difficulty and ear discharge on the continuous behaviour scores at 10 years of age—teacher reported behaviour (Rutter B scale)

Middle ear disease marker	*Antisocial*	*Neurotic*	*Inattentive*	*Clumsy*
Unadjusted magnitudes				
Hearing difficulty	0.11	0.12	−0.01	0.06
Ear discharge	0.10	0.09	0.09	0.070
Adjusted* magnitude and 95% CI				
Hearing difficulty	0.134 (0.06 to 0.21)	0.106 (0.03 to 0.18)	0.035 (−0.003 to 0.15)	0.071 (−0.04 to 011)
Ear discharge	0.108 (0.05 to 0.17)	0.081 (0.02 to 0.43)	0.072 (0.01 to 0.13)	0.069 (0.01 to 0.13)

Results are in SD units.
*Adjusted for socioeconomic status only (n = 9278).

the dichotomy at the 90th centile. Tables 7 and 9 indicate that behaviour problems at 10 years of age remain significantly associated with earlier reported ear/hearing problems.

Parental ratings: associations with ear discharge
The ORs for antisocial, neurotic, hyperactive, and clumsy behaviour all significantly reflected reported ear discharge (table 7), and were of a similar magnitude to those reported at 5 years. There was also a significant sex interaction (p = 0.01) in antisocial behaviour.

Parental ratings: associations with hearing difficulty
Reported hearing difficulty significantly raised the OR for neurotic, clumsy, and hyperactive behaviour but not for antisocial behaviour (table 9). Significant interactions were found in neurotic behaviour (p = 0.002, socioeconomic status by malaise; p = 0.03, sex by malaise), and in hyperactive behaviour (p = 0.002, sex by socioeconomic status). Although the interactions here do not involve the middle ear disease variable, they were considered important as they reflect the additional influence of synergies between the controlling variables.

The adjusted overall OR of 1.76 for hyperactive behaviour in the case of hearing difficulty is fairly large.

Teacher ratings
The teacher reported data (tables 8 and 10) show that antisocial behaviour is significantly associated with both ear discharge and hearing difficulty, but that neurotic and inattentive behaviour are not, and clumsy behaviour has only a marginal association. For antisocial behaviour, there was also a marginally significant interaction of hearing difficulty with socioeconomic status (p = 0.05). Clumsy behaviour was found to be significantly associated with hearing difficulty (p = 0.02; effect size, 0.08 SD), but not with ear discharge.

At 10 years, the verbal picture language test was significantly associated with ear discharge (p = 0.01; effect size, −0.08 SD); the negative sign indicates a deficit in language skills for children with reported ear discharge, but not with hearing difficulty. The verbal and non-verbal BAS were not significantly associated with either ear discharge or hearing difficulty. Speech articulation, as reported by the teacher, appeared significantly associated with a hearing

Table 7 Odds ratios for dichotomised parent reported behaviour scores at 10 years of age with ear discharge

Socioeconomic status (grouped)	*Antisocial*	*Neurotic*	*Hyperactive*	*Clumsy*
Unadjusted odds ratio				
1 (most advantaged)	1.24	1.27	1.57	1.44
2 (average)	1.28	1.34	1.45	1.50
3 (most disadvantaged)	1.41	1.42	1.35	0.95
Overall (95% CI)	1.36 (1.14 to 1.63)	1.35 (1.13 to 1.62)	1.45 (1.21 to 1.73)	1.31 (1.09 to 1.57)
Adjusted* odds ratio and 95% CI				
1 (most advantaged)	1.02 (0.75 to 1.82)	1.07 (0.70 to 1.64)	1.29 (0.83 to 2.02)	1.40 (0.94 to 2.09)
2 (average)	1.20 (0.90 to 1.59)	1.28 (0.99 to 1.66)	1.41 (1.10 to 1.81)	1.47 (1.14 to 1.89)
3 (most disadvantaged)	1.37 (1.04 to 1.81)	1.34 (0.95 to 1.88)	1.33 (0.97 to 1.83)	0.96 (0.61 to 1.37)
Overall†	1.26 (1.05 to 1.52)	1.26 (1.05 to 1.52)	1.37 (1.15 to 1.64)	1.29 (1.08 to 1.55)
p value for ear discharge	0.018	0.015	0.001	0.006

Results are Rutter A scale—defined at 90th centile of distribution of continuous scores.
*Adjusted for sex and maternal malaise. †Combining all socioeconomic status groups—adjusted for sex, socioeconomic status, and maternal malaise (n = 10 728).

Table 8 Odds ratios for dichotomised teacher reported behaviour scores at 10 years with ear discharge

Socioeconomic status (grouped)	*Antisocial*	*Neurotic*	*Inattentive*	*Clumsy*
Unadjusted odds ratio				
1 (most advantaged)	0.97	0.86	1.72	0.74
2 (average)	1.53	1.21	1.18	1.12
3 (most disadvantaged)	1.64	1.17	1.06	1.37
Overall (95% CI)	1.40 (1.16 to 1.68)	1.14 (0.93 to 1.38)	1.25 (1.03 to 1.52)	1.05 (0.86 to 1.28)
Adjusted* odds ratio and 95% CI				
1 (most advantaged)	0.88 (0.52 to 1.50)	0.80 (0.48 to 1.34)	1.55 (0.93 to 2.57)	0.77 (0.47 to 1.27)
2 (average)	1.51 (1.14 to 1.94)	1.15 (0.89 to 1.58)	1.13 (0.85 to 1.50)	1.14 (0.86 to 1.52)
3 (most disadvantaged)	1.76 (1.15 to 2.31)	1.16 (0.77 to 1.68)	1.06 (0.73 to 1.55)	1.34 (0.91 to 1.99)
Overall†	1.42 (1.17 to 1.73)	1.10 (0.89 to 1.35)	1.17 (0.95 to 1.44)	1.10 (0.90 to 1.36)
p value for ear discharge	0.001	0.402	0.166	0.356

Results are Rutter B scale—defined at 90th centile of distribution of continuous scores.
*Adjusted for sex and maternal malaise. †Combining all socioeconomic status groups—adjusted for sex, socioeconomic status, and maternal malaise (n = 9283).

Table 9 Odds ratios for dichotomised parent reported behaviour scores at 10 years with hearing difficulty

Socioeconomic status (grouped)	*Antisocial*	*Neurotic*	*Hyperactive*	*Clumsy*
Unadjusted odds ratio				
1 (most advantaged)	0.96	1.19	1.84	1.23
2 (average)	1.31	1.70	1.91	1.35
3 (most disadvantaged)	1.16	1.29	1.80	1.73
Overall (95% CI)	1.09 (0.87 to 1.36)	1.46 (1.19 to 1.79)	1.78 (1.47 to 2.16)	1.38 (1.12 to 1.69)
Adjusted* odds ratio and 95% CI				
1 (most advantaged)	0.88 (0.46 to 1.68)	1.12 (0.72 to 1.75)	1.69 (1.09 to 2.63)	1.21 (0.79 to 1.86)
2 (average)	1.15 (0.83 to 1.58)	1.55 (1.18 to 2.05)	1.77 (1.36 to 2.32)	1.28 (0.96 to 1.72)
3 (most disadvantaged)	1.05 (0.71 to 1.56)	1.29 (0.81 to 2.05)	1.72 (1.16 to 2.54)	1.68 (1.11 to 2.54)
Overall†	1.10 (0.87 to 1.38)	1.40 (1.14 to 1.72)	1.76 (1.45 to 2.14)	1.36 (1.10 to 1.67)
p value for hearing difficulty	0.522	0.002	0.000	0.004

Results are Rutter A scale—defined at 90th centile of distribution of continuous scores.
*Adjusted for sex and maternal malaise. †Combining all socioeconomic status groups—adjusted for sex, socioeconomic status, and maternal malaise (n = 10 750).

Table 10 Odds ratio for dichotomised teacher reported behaviour scores at 10 years with hearing difficulty

Socioeconomic status (grouped)	*Antisocial*	*Neurotic*	*Inattentive*	*Clumsy*
Unadjusted odds ratio				
1 (most advantaged)	0.73	1.38	1.06	1.61
2 (average)	1.66	0.99	1.34	0.87
3 (most disadvantaged)	1.62	1.89	0.72	2.01
Overall (95% CI)	1.30 (1.04 to 1.62)	1.20 (0.96 to 1.51)	1.06 (0.84 to 1.35)	1.23 (0.98 to 1.54)
Adjusted* odds ratio and 95% CI				
1 (most advantaged)	0.73 (0.40 to 1.35)	1.38 (0.87 to 2.19)	0.98 (0.53 to 1.81)	1.68 (1.12 to 2.53)
2 (average)	1.58 (1.18 to 2.12)	0.95 (0.68 to 1.35)	1.25 (0.92 to 1.70)	0.89 (0.62 to 1.27)
3 (most disadvantaged)	1.51 (0.96 to 2.38)	1.91 (1.22 to 2.99)	0.68 (0.39 to 1.21)	2.08 (1.32 to 3.28)
Overall†	1.38 (1.10 to 1.73)	1.25 (0.99 to 1.58)	1.07 (0.83 to 1.37)	1.31 (1.04 to 1.64)
p value for hearing difficulty	0.007	0.069	0.703	0.022

Results are for Rutter B scale—defined at 90th centile of distribution of continuous scores. Hearing difficulty by socioeconomic status interaction, p = 0.053.
*Adjusted for sex and maternal malaise. †Combining all socioeconomic status groups—adjusted for sex, socioeconomic status, and maternal malaise (n = 9324).

problem (p = 0.004; effect size, 0.13 SD) and with ear discharge (p = 0.048; effect size, 0.08 SD). All of these effects are relatively small.

The effects of reported ear discharge on the non-verbal and verbal BAS, although non-significant, were in the expected direction of slightly higher scores without discharge compared with those with discharge. On the non-verbal and verbal tests, the scores for those with reported hearing difficulty did not differ from those without.

Discussion

Recent research reviews[2 18] of otitis media developmental sequelae have highlighted the methodological difficulties and have recommended appropriate research designs. However, the gradually accumulating pattern of results in the larger and better controlled studies makes it increasingly difficult to doubt that there are OME sequelae in cognition and behaviour, although some authors[19] continue to question that such sequelae exist.

This analysis of a large national cohort extends the age range of associations reported because it has enough power to detect modest differences and provide the relevant statistical control (although in many cases this only makes a modest difference). Our analyses have shown a consistent set of effects in the behavioural scores of children by teachers as well as parents across both the ear discharge and hearing difficulty markers, suggesting that the effects from ear disease histories, as reflected by such markers, are genuine although small. Broadly, we find fewer associations with middle ear disease at 10 years than 5 years, as expected from remission of histories and the accumulation of other sources of variance.

A number of studies have considered the accuracy of parental reporting of children's disease histories.[9 20] They show that parental reporting can be fairly accurate compared with medical records, but it can be influenced by chronicity, duration of recall, and seriousness of the event.

INTERPRETATION OF PATTERNS OF RESULTS

Control for confounders

Special purpose studies can afford to include measurements that can be used to control for bias in parents' noticing both their child's health status and behavioural problems. The main reason for not believing such a possible source of artefact to be important here lies in the generally similar magnitude and pattern of results obtained when substituting ear discharge for hearing difficulty as the independent variable; we know from the analysis of socioeconomic status that hearing difficulty is subject to cultural reporting biases, but ear discharge is not. Yet, even if socioeconomic status is adjusted for, the sequelae effects found for ear discharge are no weaker overall than those for hearing difficulty, suggesting no socioeconomic status artefact. It is recognised in our analysis that statistical adjustment for socioeconomic status may not fully capture the cultural variables influencing measured abilities, thereby resulting in incomplete adjustment.

The second reason for rejecting interpretation in terms of response bias is that we find comparable results from the teacher reported data, which have greater objectivity and power.

Although the degree of control exercised here is sufficient to rule out major confounders, it does not permit all of the effects to be ascribed to particular paths of developmental influences as in the arrows of fig 1.

Behavioural sequelae

Persistent OME in early childhood, leading to prolonged auditory deprivation, appears to lead to various behaviour problems at 5 and 10 years of age. These comprise inattentive or hyperactive, antisocial, and neurotic behaviours. Behaviour problems associated with middle ear disease could come about in several ways. The main possibility is difficulty with human communication, as a result of not being able to hear properly, as mentioned earlier.[1] Other processes, mediated by generally lowered motivation and non-specific illness could also influence the behaviours reported here—for example, the child becoming withdrawn or neurotic.

Among cohort studies, only the Dunedin study[6 21] has published data on otitis media and behaviour problems. At age 5 years, 69 of the 1037 cohort members had bilateral type B tympanograms or ventilation tubes in situ. They had significantly more teacher reported behaviour problems than those with normal hearing. At ages 11 and 13, lower verbal IQ and parent and teacher reports of inattentive behaviour were associated significantly with an early history of OME.[21] However, the sample was not large enough, and the main socioeconomic gradient was too slight to test and control for interactions of OME status with socioeconomic group.

The epidemiological finding of clumsy behaviour associated with middle ear disease adds to clinical research,[22 23] suggesting possible vestibular side effects of middle ear disease. The Dunedin study[21] found deficits of motor skills from a history of middle ear disease. These unexpected deficits could be caused by vestibular dysfunction or by other factors, such as the "illness effect" of a history of upper respiratory tract infection, or to some systemic neuroimmunological factor.

Language and cognitive deficits

In the Dunedin cohort, children with bilateral OME were found to have significantly lower scores in intelligence, motor skills, verbal comprehension, and verbal expression than normal hearing children, but not in speech articulation, at 5 years. The Nijmegen longitudinal population study of 1328 children[7] found some association between OME and language development in preschool children, but this had disappeared by school age (7–8 years). This suggests short lived effects for language deficits, in line with most of the findings of more intensively studied small samples. The Boston study[8] tested speech and language in 205 children aged 3 years from a practice based cohort of 698, comparing those with little or no history of OME to those with a prolonged history. Scores were lower on receptive/expressive language, speech articulation, complexity of language, and intelligibility. By 7 years, there were still some significant associations for intelligence, speech/language, and school performance.[24]

Most of these published studies of otitis media developmental sequelae involve children young enough to show some effect of middle ear history on language delay.[25] This does not mean that all language effects in older children must be null. In a large sample with adequate control for socioeconomic status and maternal malaise, our analysis suggests that, at 10 years of age, there is a small reduction in active vocabulary associated with middle ear disease. We interpret this small effect size as consistent with transient language effects undergoing "catch up" from partial hearing or on eventual remission. An early language effect might influence the substrate of later educational achievement plus the cognitive and emotional development of the child. Further studies are required to distinguish these possibilities, but overall the conclusion remains that by school age formal language difficulties are more subtle and harder to show.

INTERVENTIONS

Our data provide a benchmark (a modest 0.2 SD) for the mean magnitude of otitis media sequelae, and indicate that clinical trials seeking to show reductions in sequelae by surgical intervention would need to be very large.

An alternative view of effects around 0.2 SD is that about 5% of all children (that is, half the materially affected children) have effects larger than this, so our conclusions for the general case do not mean that otitis media is universally benign. Parental and teacher awareness and close monitoring is required in all cases, as is intervention in extreme cases (surgical treatment or behavioural management). Criteria for referral to speech and language therapists or psychologists would need to be formulated and tested in trials. As with medical interventions, the problem of structuring and specifying the interventions of the various professionals involved, to ensure that they are efficacious and amenable to rigorous evaluation for effectiveness, will be great.

We are grateful to the social statistics research unit at City University, London for supplying the documented data and to the Hearing Research Trust for supplementary financial support (Defeating Deafness).

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