Prevalence of autism-spectrum conditions: UK school-based population study

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Background
Recent reports estimate the prevalence of autism-spectrum conditions in the UK to be 1%.

Aims
To use different methods to estimate the prevalence of autism-spectrum conditions, including previously undiagnosed cases, in Cambridgeshire.

Method
We carried out a survey of autism-spectrum conditions using the Special Educational Needs (SEN) register. A diagnosis survey was distributed to participating schools to be handed out to parents of all children aged 5–9 years. The mainstream primary school population was screened for unknown cases.

Results
The prevalence estimates generated from the SEN register

and diagnosis survey were 94 per 10 000 and 99 per 10 000 respectively. A total of 11 children received a research diagnosis of an autism-spectrum condition following screening and assessment. The ratio of known:unknown cases is about 3:2 (following statistical weighting procedures). Taken together, we estimate the prevalence to be 157 per 10 000, including previously undiagnosed cases.

Conclusions
This study has implications for planning diagnostic, social and health services.

Declaration of interest
F.J.S acted as an expert witness for the diagnosis of autism-spectrum conditions and for the measles, mumps and rubella vaccine litigation, but not for children in the population covered by this study.

In ICD–10, autism-spectrum conditions are diagnosed by the presence of social and communication difficulties, alongside unusually strong, narrow interests and/or repetitive and stereo-typed behaviour.[1] In childhood autism, language delay is invariably present and cognitive ability may extend into the below-average range (intellectual disabilities). In Asperger syndrome, language develops at a typical age (single words by 2 years, phrase speech by 3 years) and cognitive ability is in the average range or above. Other subgroups include atypical autism (atypical in terms of late age at onset, atypical symptoms or subthreshold symptoms) and pervasive developmental disorder 'other' (PDD other) (in which autistic features are present but criteria for autism, Asperger syndrome and atypical autism are not met). There is no corresponding classification of atypical autism in DSM–IV,[2] although this diagnosis may fall under pervasive developmental disorder not otherwise specified.

We favour use of the term 'autism-spectrum condition' rather than 'autism-spectrum disorder' as it is less stigmatising, and it reflects that these individuals have not only disabilities which require a medical diagnosis, but also areas of cognitive strength. There is no clear demarcation between these conditions and continuously distributed autistic traits in the general population. The threshold for diagnostic purposes is set at the level where autistic traits are significantly interfering in daily life functioning, determined by clinical judgement. Traditionally, autism was conceptualised as a categorically distinct condition, but this view has been challenged and it has been proposed that autistic traits are continuously distributed in the population.[3–8] According to this view, the autism-spectrum condition is an extreme of the normal variation of autistic traits.

Prevalence estimates for autism-spectrum conditions have shown a steady increase over the past four decades. In 1978, the

consensus estimate for classic autism was 4 in 10 000; today autism-spectrum conditions (including classic autism) affect approximately 1% of the population.[9,10] This massive increase is likely to reflect seven factors: improved recognition and detection; changes in study methodology; an increase in available diagnostic services; increased awareness among professionals and parents; growing acceptance that autism can coexist with a range of other conditions; and a widening of the diagnostic criteria.[11–16]

There have been a series of prevalence studies over the past decade,[17–19] reviewed elsewhere.[15] Results cannot be directly compared because of varying methodologies in terms of case-finding, sampling and the diagnostic definitions used. To highlight this point, a Finnish study used a population screening approach to estimate the prevalence of Asperger syndrome (rather than the whole autism spectrum).[20] The Autism Spectrum Screening Questionnaire (ASSQ)[21] was completed by parents and/or teachers on 81% of children at age 8 from a population of 5484. Depending on which diagnostic criteria were applied, prevalence estimates for Asperger syndrome ranged from 16 to 43 per 10 000 (i.e. approaching 0.5% just for the Asperger subgroup). Further studies have been conducted at different times and in different populations. Few studies have employed prospective serial ascertainment of cases to determine prevalence.

One recent study screened individuals at risk for autism-spectrum conditions and estimated prevalence to be 116 per 10 000 children aged 9–10 in the South East Thames Region (UK), or approximately 1% of the child population.[10] By screening only children at risk (using the Special Educational Needs (SEN) register) it is possible that in this study, cases of autism-spectrum conditions were missed because they were not on the register. In the UK, the SEN register includes children who require access to additional support beyond that provided by the school's usual differentiated curriculum. Many (but not all) children on the SEN register receive a 'Statement of special

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educational needs' (a Statement). This sets out a child's needs and the help they should have to support them in school. It is reviewed annually to ensure that any extra support given continues to meet the child's needs.

In the present study, we aimed to explore contrasting approaches to estimate the prevalence of autism-spectrum conditions in a defined population (Cambridgeshire). We investigate whether the 1% estimate reported by Baird et al[10] is generalisable in the UK. We used a novel approach by screening the mainstream primary school population to detect potential clinically undiagnosed cases of autism-spectrum conditions. We report prevalence estimates of autism-spectrum conditions defined as: autism + atypical autism + Asperger syndrome + PDD other. We also report prevalence estimates for childhood autism (where possible) so that comparisons can be made with other studies.

Method

The study was approved by the local research ethics committee, Addenbrooke's Hospital, Clinical School, Cambridge. The sponsor of the study had no role in study design, data collection, data analysis, data interpretation or writing of the report. S.B-C. had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Special Educational Needs (SEN) register count

All schools within the county of Cambridgeshire, including mainstream and special schools in both the state and the private sectors (serving the population of Cambridge City, East Cambridgeshire, South Cambridgeshire, and Fenland districts), were invited to participate in the study. These geographical areas cover a broad cross-section including urban and rural areas. Special schools in the county accept children who have moderate, severe or profound intellectual disability, emotional and behavioural difficulties, and autism-spectrum conditions. Those schools that agreed to take part were asked to provide a count of the number of children aged 5–9 years old (school years 1–4) and the number recorded on the SEN register as having an autism-spectrum condition diagnosis. Based on the available quality of information in this register, best estimate autism-spectrum condition diagnostic subgrouping using ICD–10 research criteria was carried out.

Direct school population screening

The schools that agreed to take part in the study were asked to distribute a questionnaire pack to parents of all children in the school aged 5–9 years. The total number of questionnaires requested by all schools (mainstream and special) was 11 700. It was therefore assumed that this was the total number of the schooled population that was surveyed in this study. The pack contained a diagnosis survey (online Appendix DS1), the Childhood Autism Spectrum Test (CAST)[8,22] (formerly the Childhood Asperger Screening Test; here the same acronym and the items are retained, but the title has been modified to reflect that the same instrument can be used to detect all autism-spectrum conditions and not just Asperger syndrome), as well as standardised questions about parental education and socioeconomic status.[23] The diagnosis survey enquires about various diagnoses that the child may have received, by whom these were made, along with any developmental or behavioural concerns expressed by teachers or other professionals.

The CAST was used as a screening instrument to identify those with high and borderline scores with no pre-existing diagnosis. The CAST is a 37-item parental self-completion screening

questionnaire and has a scoring range from 0 to 31. For the 31 scoring items, an autism-positive response scores 1 and an autism-negative response scores 0. Some items are reverse scored so that not all 'yes' responses score 1. The remaining six items are control questions on general development and are not scored. The cut-point for concerns of possible autism-spectrum condition is 15 or higher. At that cut-point, sensitivity has been shown to be 100%, specificity 97% and positive predictive value 50% using research diagnostic assessments (Autism Diagnostic Observation Schedule (ADOS)[24] and Autism Diagnostic Interview – Revised (ADI–R[25])).[22] The CAST shows moderate to good test–retest reliability.[26,27] Scores also show heritability.[28] The CAST can be recommended as a screening instrument for use in epidemiological studies, but not as a general screening tool at a population level owing to the high number of false positives.[22] This is a function of the low prevalence of autism-spectrum conditions in the general population and therefore the CAST has a low positive predictive value. The CAST in full has been published elsewhere.[8]

The cover letter explained that the research team was interested to hear from parents of all children aged 5–9 years, not just those with concerns about their child. The questionnaire pack was distributed to participating schools in six batches, with a batch being distributed every 2 months between February 2003 and March 2004. This was taken home for parental completion and returned directly by Freepost to the research team. Reminder letters were also distributed to participating schools, who were asked to give them out about 2 weeks later. A total of 1452 questionnaires were sent in Batch 1 and 404 (28%) were returned; 2195 were sent in Batch 2 and 610 (28%) were returned; 2686 were sent in Batch 3 and 805 (30%) were returned; 1539 were sent in Batch 4 and 592 (38%) were returned; 2119 were sent in Batch 4 and 512 (24%) were returned; and 1644 were sent in Batch 6 and 481 (29%) were returned.

Returned questionnaires were excluded from analyses if: (a) they were from parents of children from schools not invited to take part in the study (parents may have accidentally completed the questionnaire for another child attending a different school); or (b) the children were older or younger than those approached, allowing a margin of 1 year younger and older than the lowest and oldest ages expected.

All children whose parent had reported an existing autism-spectrum condition diagnosis on the diagnosis survey were excluded from the assessment phase in order to maximise available resources. The number of children whose parents reported on the diagnosis survey that their child had an autism-spectrum condition diagnosis was counted. Only these families were sent a further form asking for full information about their child's diagnosis. This included the subgroup diagnosis (if known), the clinic where the child was diagnosed, the name of the clinician who made the diagnosis and the date of the diagnosis. A child whose parents reported a clinical diagnosis of autism-spectrum condition that was consistent with their original report was considered to be a confirmed case. Only those children who had been diagnosed by a relevant health professional (e.g. paediatrician, psychiatrist, clinical psychologist) were confirmed as a case.

Every child scoring above the cut-point of 15 on the CAST, as well as a randomly selected 33% of 12–14 (borderline) scorers, were invited for a detailed assessment to establish how many undiagnosed cases of autism-spectrum condition there might be in the population. We were then able to calculate the ratio of undiagnosed:diagnosed cases. In total, 33% of borderline scorers were chosen as this was sufficient to enable estimation of undiagnosed cases in this score band without overloading the team's assessment capacity. No child scoring ⩽11 was sampled

for assessment and all in this score band were assumed to not have autism. These sampling bands were chosen because our previous studies suggest that no children scoring ≤11 points are diagnosed with an autism-spectrum condition, whereas children on the borderline of the cut-point (12–14) may show some social and communication difficulties.[8,22]

Where there were missing CAST data, the midpoint score was used; that is, the maximum score (calculated by recoding missing items to one) plus the observed score (all missing data treated as if the item score would have been zero) divided by two. Although there are numerous methods to treat missing data, we decided that such an approach should be adopted to ensure maximum capture of cases from incomplete CAST questionnaires for the purposes of sampling. Five children were not invited for assessment, since the amount of missing data in their screens was considered excessive as the maximum and the observed scores were discrepant by more than 5 points.

Diagnostic assessment

Assessment consisted of a standardised interview (ADI–R[25]) with the parent or primary caregiver and a standardised observation (ADOS[24]) with the child. The ADI–R and ADOS were administered by members of the research team trained in the use of these instruments to reliability levels for research purposes. All assessors were unaware of CAST scores at the time of assessment. A random selection of assessments (35%) were video- and audiotaped. IQ data were not collected, which is a limitation of this study. However, developmental delay was established using the background and introductory items in the ADI–R, and communication impairment was established using items 9 and 10 in the ADI–R.

Case definition

Following face-to-face assessment, cases were defined in two ways: (a) an assessment diagnosis strictly based on meeting ADI–R and ADOS algorithm criteria; and (b) a consensus diagnosis, based on information obtained through the ADI–R and ADOS in conjunction with the clinical judgement of members of the research team. The latter is recommended because the ADI–R and ADOS alone are less reliable in detecting more subtle cases of autism-spectrum condition (the ADI–R only provides a cut-point for classic autism[25,29]). A case definition for wider-spectrum conditions including Asperger syndrome and PDD other was required for maximum capture of all autism-spectrum cases. For all children who received a consensus autism-spectrum condition diagnosis, a review of their assessment data was conducted so that cases could be subdivided into the four major diagnostic subgroups using ICD–10 research criteria.

Results

The SEN register

A total of 162 schools (142 state, 13 private mainstream schools, and 7 special schools) were approached. Of these, 96 schools (86 state and 6 private mainstream, and 4 special schools) agreed to participate in the study (Fig. 1). For simplicity, state and private mainstream schools (non-special schools) were merged for analysis and labelled as 'mainstream'. Schools across Cambridgeshire were grouped geographically (between 14 and 33 schools per group) and invited across six time points (about every 2 months) between February 2003 and March 2004. School participation at each time point ranged from 46 to 71% but there were no noted differences in geographical distributions of schools that participated *v.* schools that refused. Overall, 79 out of the 92 mainstream schools and

none of the 4 special schools reported the number of children with autism-spectrum condition from their SEN register. In total, 8824 children were attending the 79 schools. Since 11 635 questionnaires were distributed to schools, it was assumed that 2811 children attended the 13 schools that did not report the number of children with autism-spectrum condition on the SEN register. In total, 83 cases of autism-spectrum condition were reported from the 79 schools (Fig. 1), 10 of which were reported to be childhood autism. It was not possible to verify the reported diagnoses from the SEN register since legislation regarding data protection would not allow this. Further, no information was provided regarding gender distribution of the 83 cases.

To estimate prevalence using data from the SEN register, exact binomial methods were used to calculate 95% confidence intervals. For childhood autism, this gives a prevalence estimate of 11 per 10 000 (95% CI 5–21). For all autism-spectrum conditions, this gives a prevalence estimate of 94 per 10 000 (95% CI 75–116) or 1 in 106.

Diagnosis survey and CAST population and response

In total, 11 635 questionnaire packets were distributed to participating mainstream schools, one to each child in school years 1–4. Of these, 3370 were returned; 28 questionnaires were excluded because they were outside the age range approached or from a non-participating school, leaving 3342 diagnosis surveys and CAST questionnaires from mainstream schools for analysis (response: 29%).

In addition, 65 questionnaires were distributed to participating special schools, as this was the number of children who were aged 5–9 years at the time of the survey, and 31 were returned (48%). All but one of the special schools had fewer than 100 pupils on the roll at the time of the survey, and the age range of pupils in special schools is wider than for mainstream schools. For example, one school accepts children and young adults from age 2 to age 19.

Thus, altogether there were 3373 questionnaires available for analysis (response: 29%). Of these, 1683 (50%) were for boys and 1672 (50%) were for girls, and for 18 (1%), gender was not stated by the parent/guardian. Table 1 provides the age distribution and demographic details of the screened population. Table 2 indicates that the population is biased towards Social Class I (around 50% coming from this social class). Regarding the
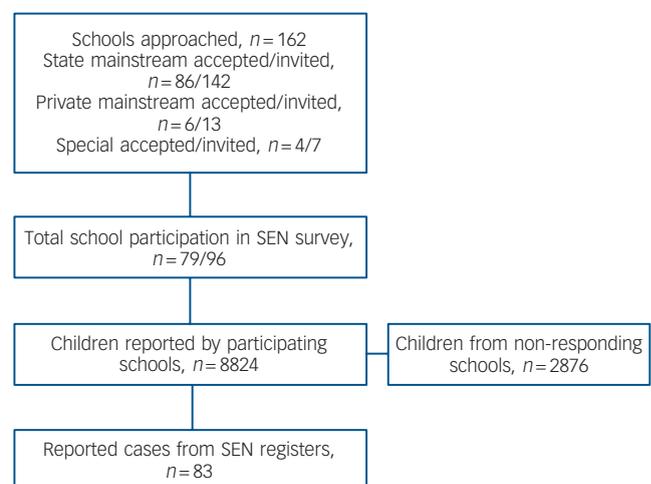
Fig. 1 Special Educational Needs (SEN) register: methods and results.

Table 1 Age distribution of children whose parents returned a diagnosis survey and a Childhood Autism Spectrum Test (CAST) questionnaire

Age, years	n (%)
4	42 (1.3)
5	529 (15.7)
6	856 (25.5)
7	888 (26.4)
8	741 (22.0)
9	246 (7.3)
10	11 (0.3)
Missing	51 (1.5)

Table 2 Socioeconomic classification of parents who returned a diagnosis survey and a Childhood Autism Spectrum Test (CAST) questionnaire

Social class	Caregiver 1, n (%)	Caregiver 2, n (%)
I: managerial and professional	1674 (49.8)	1658 (49.3)
II: intermediate occupations	510 (15.2)	30 (0.9)
III: small employers and own account workers	194 (5.8)	444 (13.2)
IV: lower supervisory and technical occupations	120 (3.6)	385 (11.4)
V: semi-routine and routine occupations	319 (9.5)	199 (5.9)
Never worked	22 (0.7)	2 (0.1)
Missing	525 (15.6)	646 (19.2)

number of parents educated to degree level or higher (leaving education at age 21 or later), 956 of the 3373 responders (29% of the current sample) fit this category. This is similar to the 2001 census data for Cambridge, Cambridge East and Cambridge South, which indicates that 32% of the total population from those areas was educated to degree level or higher.[30]

Reported cases of autism-spectrum conditions

Overall, 41 cases of autism-spectrum conditions were reported by parents using the diagnosis survey: 37 from mainstream schools and 4 from special schools (Fig. 2). All cases from special schools were assumed confirmed since entry to a special school would require extensive assessment of individual special needs. Of the 37 cases reported from mainstream schools, 24 (65%) parents replied to the request for further information providing details of the reported diagnosis. Two children had not actually received diagnoses. Of the remaining 22 cases, 19 (16 boys, 3 girls) included information consistent with having a diagnosis of an autism-spectrum condition (the 3 other parent-reported cases were too vague to assign an ICD–10 classification) (Fig. 2). The ratio of confirmed:reported cases from the diagnosis survey was therefore 19:24.

All reported diagnoses (from the diagnosis survey) were adjusted by the ratio of confirmed:reported. 'Confirmed' refers to those parents who not only reported that their child had a diagnosis of an autism-spectrum condition but who also replied to the request for further information, and where this further information was consistent with their initial report. This provided a weight to apply to this group, giving an estimate of known cases within the screened population. Using the weight of 19/24 as an index of diagnostic validation, we can adjust for possible slight
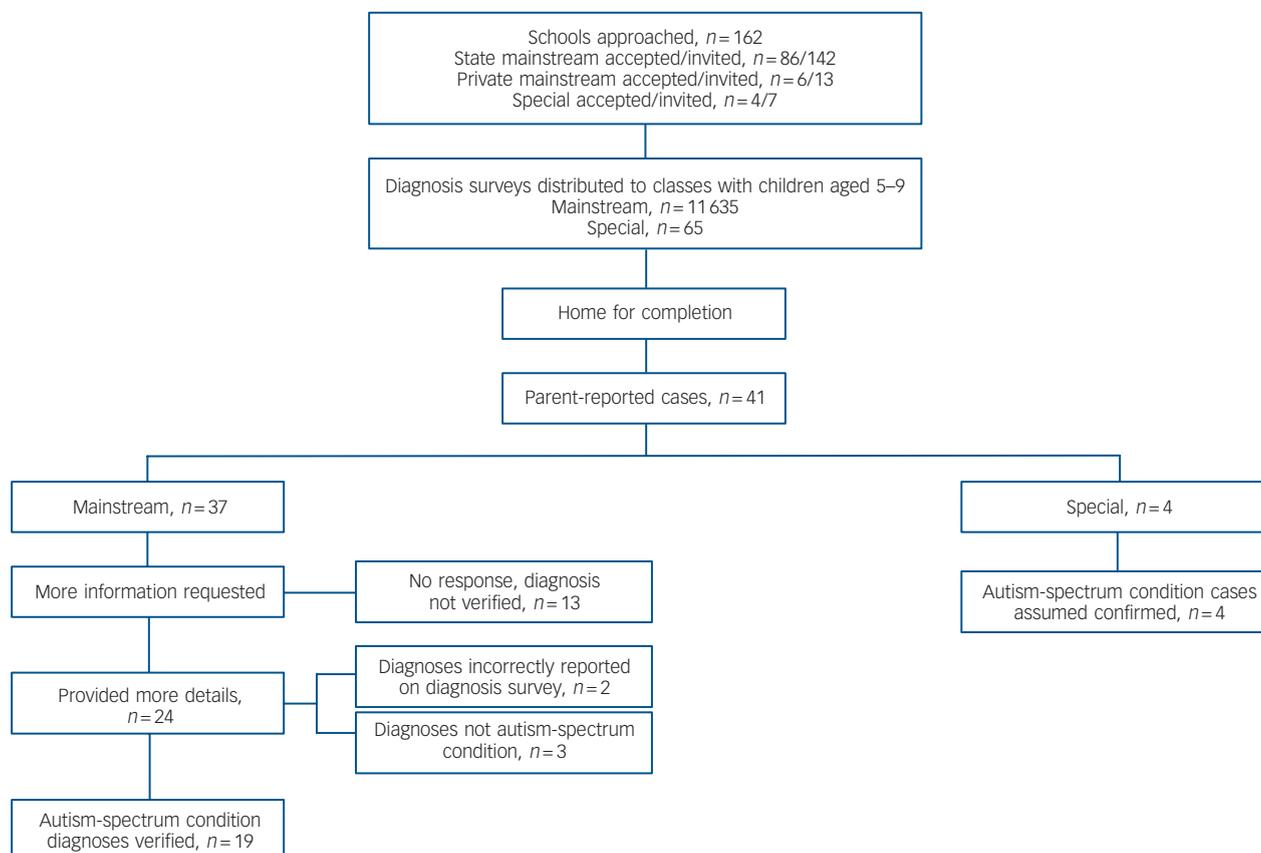
Fig. 2 Diagnosis survey: methods and results.

overreporting by the 13 parents who reported that their child (9 boys, 5 girls) had a diagnosis of an autism-spectrum condition from the diagnosis survey but who did not reply to the request for further details (assuming the rate of confirmation of diagnosis is the same in the non-responders). On this basis, the overall parent-reported prevalence estimate is $13 \times (19/24) + 19$ (confirmed cases) + 4 (special school cases: 3 boys, 1 girl). This equates to 33.3 known cases in the screened population.

To estimate prevalence, confidence intervals were calculated using 1000 non-parametric bootstrap samples,[31] reporting percentile confidence intervals (95% CI 2.5–97.5). This allows the confidence intervals to be asymmetrical about the prevalence estimate and includes the uncertainty of the weighted estimate. This gives a prevalence estimate of 99 per 10 000 (95% CI 65–141) or 1 in 101. For boys and girls separately, the prevalence estimate is 153 per 10 000 (95% CI 94–217) or 1 in 66 and 42 per 10 000 (95% CI 9–79) or 1 in 208 respectively.

Of the 41 children whose parents reported a previous diagnosis of an autism-spectrum condition, all (100%) from the special school sample ($n=4$) scored above the cut-point of 15 on the CAST (range 18–28, using the midpoint score). In total, 30/37 (81%) children who were reported by parents as having an autism-spectrum condition diagnosis from the mainstream school sample scored above the cut-point of 15 on the CAST and 4 (10.8%) children scored 12–14. Two (5.4%) children scored $\leqslant 11$. Of these, one parent replied to the request for further information and the child was confirmed as not having autism-spectrum condition. In the other case, the parent replied to the request for further information, which was consistent with an autism-spectrum condition diagnosis and was thus treated as a confirmed case. All children whose parents initially reported that their child had a diagnosis were excluded (before the request for further information was made) from the assessment phase owing to resource limitations.

Sampling

From the screened population (excluding those with an autism-spectrum condition diagnosis reported on the diagnosis survey), 90 children scored $\geqslant 15$ on the CAST and were invited for assessment. Of these, 52 (58%) attended. Overall, 122 children scored 12–14 on the CAST and 33% were invited for assessment.

Of these, 25 (63%) attended. Thus, 77 research assessments were undertaken. Of these, 8 were of children from special schools and 69 from mainstream schools. There were no significant differences between those who accepted and those who refused the invitation for assessment in terms of CAST score, gender, age of child or concerns expressed by professionals (all $P > 0.2$). Ten (eight boys, three girls) children who scored $\geqslant 15$ and one (boy) who scored 12–14 were given a research diagnosis of an autism-spectrum condition. Of these 11 children, 4 met algorithm criteria on both the ADOS and the ADI–R (including the child who scored 14 on the CAST) and 5 met criteria on either the ADI–R or the ADOS, but not on both. The other two children did not meet algorithm cut-points on either instrument but were showing clear difficulties in all three areas of the diagnostic 'triad' (social interaction difficulties, communication difficulties, and/or repetitive and stereotyped behaviours and interests) and were given a consensus autism-spectrum condition research diagnosis. Thus, 11 out of 77 assessments resulted in a consensus diagnosis of autism-spectrum condition, of which 4 resulted in a consensus diagnosis of childhood autism. This suggests that diagnosis was cautious and conservative. Table 3 provides full assessment scores for the 11 identified cases of autism-spectrum condition. Figure 3 shows the study flow from the CAST screening and assessment phase.

Inverse probability weighting methods were used to adjust the prevalence estimates for the known non-response to the invitation for assessment within each sampling score band, and for the 33% random sampling for face-to-face assessment among the borderline scorers from the CAST screening. As described earlier, assessment invitations were weighted towards the high scorers. Low scorers (score $\leqslant 11$) were assumed to have no new cases since no cases of autism-spectrum conditions were identified in previous studies of children scoring $\leqslant 11$.[8,22] Using the weightings of 90/52 (90 children who scored $\geqslant 15$ on the CAST and 52 children in this score band who participated in the assessment) and 122/25 (122 children who scored 12–14 on the CAST and 25 children in this score band who attended for a research assessment), the overall directly observed prevalence estimate for all autism-spectrum conditions is $(10 \times (90/52)) + (1 \times (122/25))$, which corresponds to 22.2 new (undiagnosed) cases from the screened population.

Table 3 Assessment results for 11 ascertained cases of autism-spectrum conditions from Childhood Autism Spectrum Test (CAST) screening

| Child | Gender | CAST score[a] | ADOS | | | ADI–R | | | | Research diagnosis |
			Communi-cation	Social interaction	Stereotyped behaviour/ repetitive interests	Communi-cation	Social interaction	Stereotyped behaviour/ repetitive interests	Abnormal development	
1	Male	23	1	2	4	7	12	2	2	PDD other
2	Male	14	3	8	1	17	23	5	5	Autism (HFA)
3	Male	25	4	7	1	18	13	8	3	Autism (HFA)
4	Female	15	4	10	7	13	19	5	5	Autism
5	Male	29	1	5	2	16	25	9	4	Asperger syndrome
6	Male	22	1	1	0	11	9	9	2	PDD other
7	Male	23	1	2	4	12	10	5	5	Atypical autism
8	Male	28	2	6	3	16	26	6	1	Asperger syndrome
9	Male	20	1	2	2	16	17	4	4	Asperger syndrome
10	Male	18	3	2	1	12	12	7	5	Asperger syndrome
11	Male	17	6	10	2	17	8	3	3	Autism (HFA)

ADI–R, Autism Diagnostic Interview – Revised; ADOS, Autism Diagnostic Observation Schedule; HFA, high-functioning autism; PDD other, pervasive development disorder other.
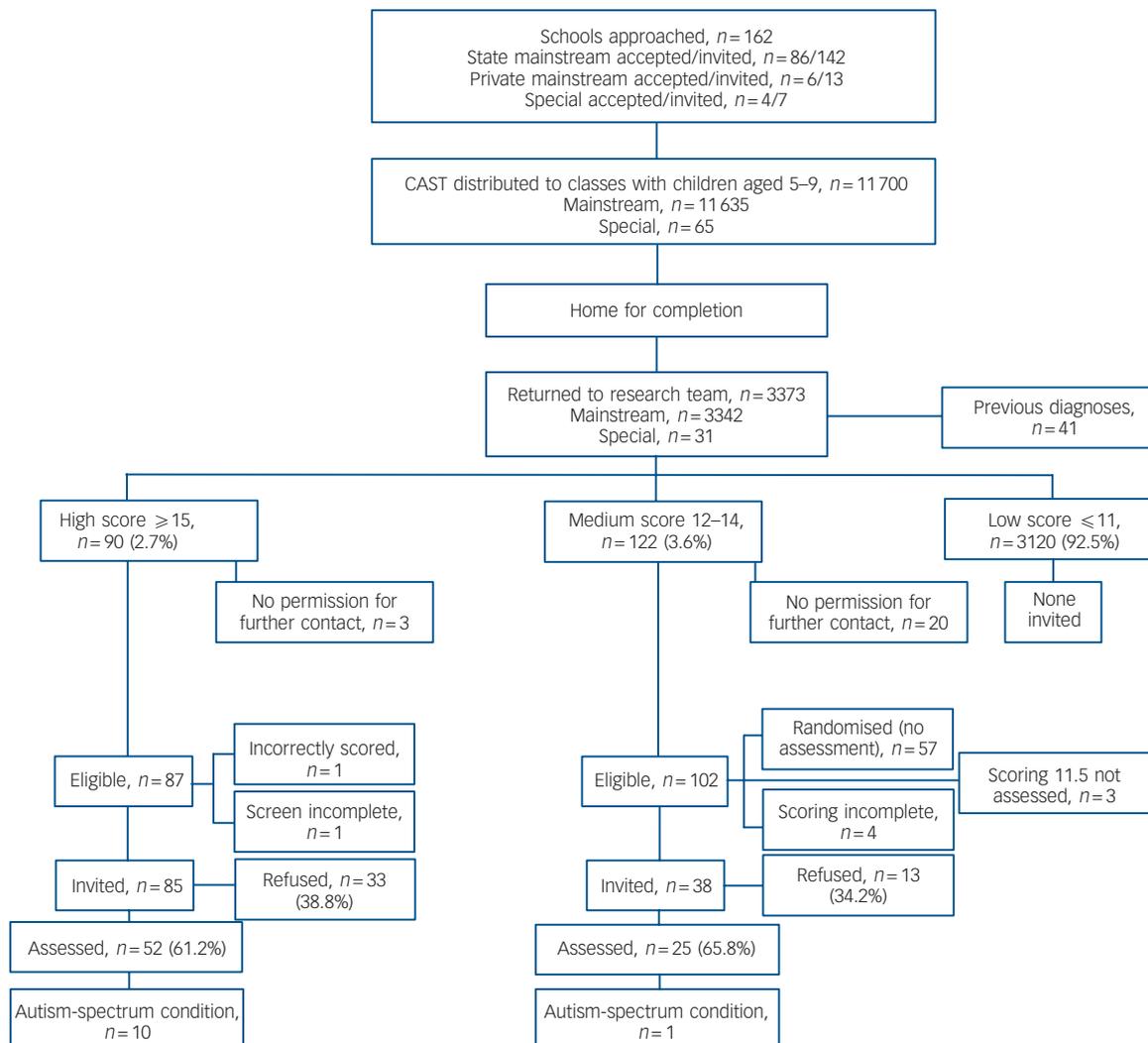a. Maximum score of 31.

Fig. 3 Childhood Autism Spectrum Test (CAST) screening: methods and results.

Calculating the ratio of known:unknown cases of autism-spectrum conditions

This ratio is calculated by adding the 33.3 known cases of autism-spectrum conditions from the diagnosis survey data and the 22.2 new research cases from the CAST screening and assessment, which amounts to 55.5 total cases. Dividing this by 33.3 (known cases) gives 1.67 as a multiplier that can be applied to prevalence estimates generated from studies that screen the primary population for known cases of autism-spectrum conditions (95% CI 1.24–2.32). For boys, the ratio is calculated by adding 19.2 (weighted number of male new research cases from the CAST) and 25.7 (weighted number of male known cases from the diagnosis survey), amounting to 44.9 total cases of autism-spectrum conditions in boys. This can be divided by the known male cases (25.7) to give 1.75 (95% CI 1.3–2.6) as the multiplier that can be applied for boys. For girls, the calculation is 3.0 (weighted new female research cases) added to 7.0 (weighted known cases from the CAST) divided by 7.0. This gives a multiplier of 1.43 (95% CI 1.1–3.3). Overall, for boys and girls together, for every three known cases, there are at least two undiagnosed cases of autism-spectrum conditions in the primary school population, or a ratio of 3:2 (known:unknown). There is no evidence of a difference in the undetected estimate of cases for boys and girls, despite a clear difference in the overall ratio of boys:girls with autism-spectrum conditions.

Combining estimates and sensitivity analysis

Data from the SEN register and the diagnosis survey estimated the prevalence of known cases of autism-spectrum conditions, whereas data from the CAST screening and assessment estimated the number of unknown cases. It is not surprising that over 60% of children in the assessment phase were given a consensus diagnosis of an autism-spectrum condition (rather than childhood autism) since cases of lower functioning (childhood autism) are more likely to have been detected by school age. Of those who received a consensus diagnosis of childhood autism, three-quarters were described as 'high-functioning' and met ICD–10 research criteria for this category because these children had a delay in language (so could not be classified as having Asperger syndrome) with no reported cognitive impairment.

By adjusting the estimate derived from the SEN register (that is, based on whole classes and not a 29% response) for the additional number of cases that would be expected if all the children were directly observed, the prevalence estimate is 157 per 10 000 or 1 in 64 (95% CI 99–246).

Study weights were adjusted to reflect the fact that special schools and mainstream schools had a slightly different response. The bias introduced by the 29% response among parents cannot be directly estimated. Two assumptions that are expected to be lower and higher than our point estimate are: (a) there were no cases in the non-responders; and (b) data are missing at random, such that the non-responding population would have the same distribution on the CAST as the responding population. Both are unlikely and produce very different values. An intermediate position is to assume that there is a 'worried parent' effect; in this case we assumed that there is a twofold increase in response in parents whose child scored on the CAST in the high or medium range (worried parents). Therefore, three sensitivity estimates from the CAST screening and assessment are provided.

Adjusting for the school non-response made no change to the prevalence estimates. The extreme sensitivity analyses, as expected, provide widely divergent estimates. If we assume there were no cases in the non-responders, the estimate is 47 per 10 000 (95% CI 32–63). If we assume non-responders had the same distribution of scores on the CAST as the responders, the estimate is 165 per 10 000 (95% CI 111–218). Assuming an increased response from parents of children with higher scores on the CAST (the 'worried parents' assumption) reduces the estimate, as expected, to 113 per 10 000 (95% CI 76–149).

The different methods provide a range of estimates which, including sensitivity analyses, range from 47 to 165 per 10 000 children aged 5–9 years old. The two estimates that appear least

biased are: (a) the estimate based on the multiplier from the CAST screening and assessment applied to the SEN register estimate (the ratio of known:unknown cases, 1.67×94); and (b) the estimate that makes a reasonable assumption about a possible response bias from postulated worried parents. These provide the estimates of 157 and 113 per 10 000 respectively.

The data converge on the conclusion that, despite differences in methodology, the prevalence of known cases of autism-spectrum conditions is slightly above 1%. The prevalence estimates generated are shown in Fig. 4.

Discussion

This paper reports prevalence estimates of autism-spectrum conditions in children aged 5–9 in a total population using various methods of ascertainment, and provides a multiplier that may be applied to other prevalence estimates generated from studies that include known cases of autism-spectrum conditions. This is a novel approach to estimating the prevalence of these conditions and presents strong evidence that undiagnosed cases do indeed exist in the school-aged population. The estimates of known cases reported in this paper accord with previous prevalence estimates,[10,32,33] converging at around 1%. Further, prevalence estimates reported from other countries fall within the confidence intervals of our estimates reported in this paper.[17,34,35]
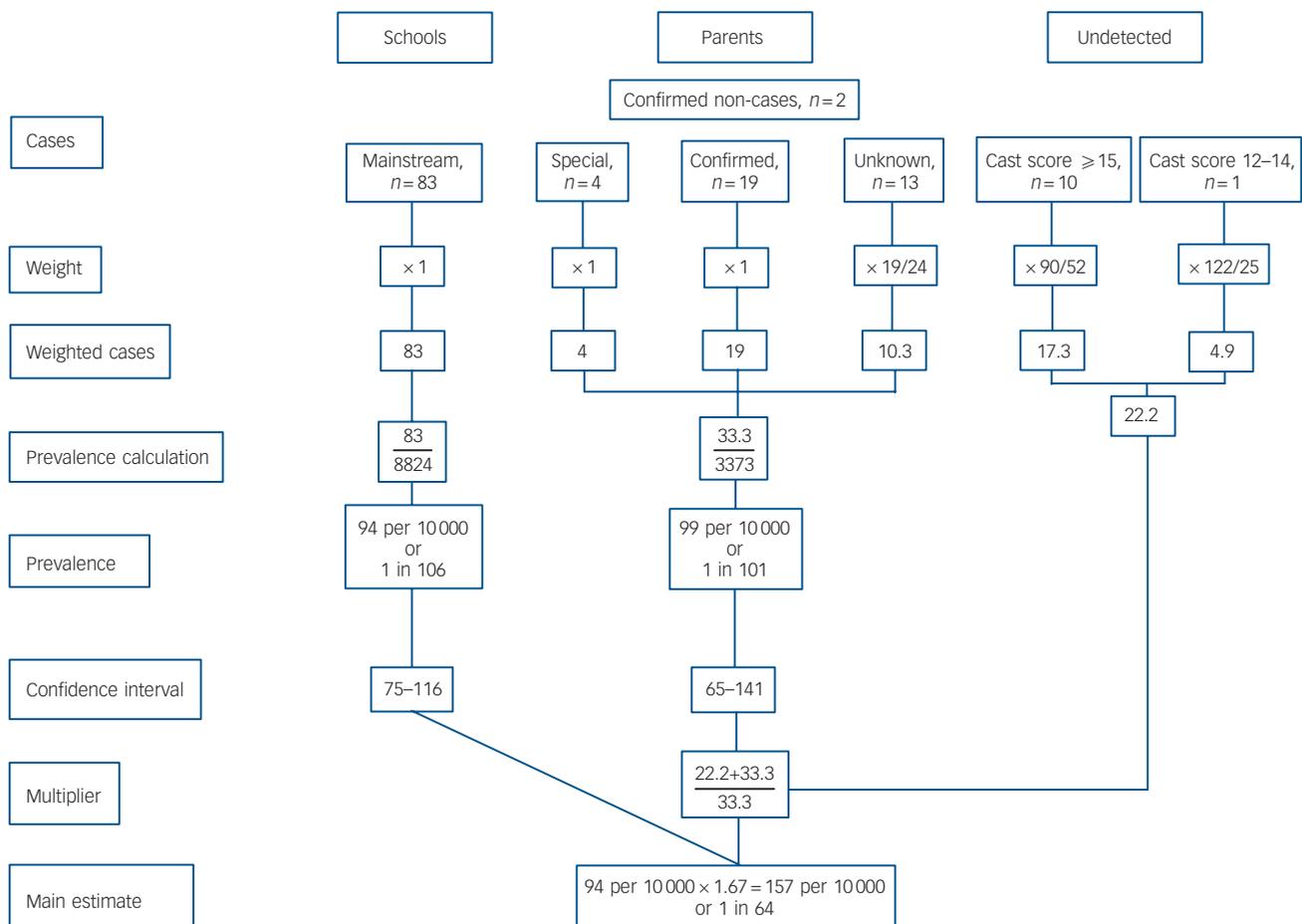

Fig. 4 Summary of prevalence estimates from Special Educational Needs (SEN) register and diagnosis survey, and calculation of the multiplier from Childhood Autism Spectrum Test (CAST) screening.

Despite the differences in methodology of counting cases from the SEN register and as reported by parents from the diagnosis survey, the data suggest that the prevalence estimate for all autism-spectrum conditions remained at about 1% (taking into account confidence intervals) regardless of which method was used. There are a number of limitations to the study and caution when generalising these results must be taken. First, the response from parents was quite low, although this is consistent with unsolicited surveys that require a postal opt-in. The level to which low response is considered acceptable is arbitrary. The amount of bias that could be attributed to the non-responders is unknown and we were unable to measure this. For a rare condition, even a small handful of cases in the non-responders can dramatically alter the prevalence estimates.[36] Despite adopting strategies to attempt to increase the response (sending a reminder letter, asking the school to advertise the study in their newsletter), the response remained constantly low throughout the study. Owing to the large-scale nature of the study and the consequent resource limitations, we were unable to offer any incentive for returning the questionnaire. By definition, we cannot know how the non-responder section of the population would have replied and can therefore only make a limited number of reasonable assumptions: for example, that there are more high scorers in the non-responders as has been found in a previous study using the ASSQ.[21,37] However, we chose to estimate prevalence cautiously and not perform sensitivity analyses that would further inflate the estimates. After the screen, non-response bias to assessment can be adjusted through weighting procedures and this made little difference to our final estimates.

Second, we did not subclassify the school- and parent-reported diagnoses beyond separating them into childhood autism and other autism-spectrum conditions. Until the diagnostic criteria for the other subtypes of autism (such as PDD other and atypical autism) have been clearly operationally defined with clear algorithms for these conditions, it remains very difficult to accurately estimate prevalence of these conditions within the autism spectrum. Only 4 out of the 11 cases that we identified met criteria on both diagnostic instruments. This study provides further evidence that, although helpful, the ADOS and ADI–R are not adequate measures for the diagnosis of all autism-spectrum conditions. Clinical judgement continues to play an important role in determining and interpreting the level of impairment an individual has, to warrant a clinical diagnosis of autism-spectrum condition.

Third, we did not have resources to independently verify whether the diagnoses were accurately reported by schools and by parents. This would have involved a labour-intensive assessment period that was beyond the scope of this project. Clearly, it remains plausible that both schools and parents might inaccurately report diagnoses. Independent verification would have provided us with more precise information to estimate prevalence and potentially lower the estimates. It was assumed that cases reported by schools would require a formal diagnosis to be recorded on the SEN register, but it remains a possibility that some schools reported children as 'cases' when they do not in fact have a formal existing clinical diagnosis. This potential over-reporting bias may be balanced by the lack of response from special schools for this source; the prevalence of autism-spectrum conditions is much higher in special schools, although they only serve a very small percentage (about 0.69% of children aged 5–9[38]) of the schooled population. This may further be balanced by underreporting in the mainstream population, whereby autism-spectrum conditions have not yet been recorded on the child's Statement and the SEN register, along with children with high-functioning Asperger syndrome who do not have a

Statement. Further research is warranted to assess how reliably parents and schools report diagnostic information.

Overall, there was no evidence for a difference in the number of undetected cases of boys and girls. Notwithstanding this, all of the children who received a consensus research autism-spectrum condition diagnosis were male, except for one child. It has been well documented in the literature that a higher prevalence of autism-spectrum conditions is found among males,[39,40] and that there are differences in social and communication development between boys and girls.[41,42] However, this may in part be accounted for by the measurement instrument and sampling procedure, and not be a reflection of a possible true difference in the number of clinical but undiagnosed boys and girls. The CAST may be more efficient at detecting difficulties in social and communication development in boys than girls.[43] Further, more sensitive questions may be required in order to detect subtle difficulties in girls such as trying to fit in with peers.[44] Girls may be missed by instruments such as the CAST as some autistic features (e.g. circumscribed interests) may be more social in nature in girls than in boys,[45,46] making them less obvious. There is a need for better instruments that identify the phenotypic differences and difficulties that are specific to girls.

The findings from this study based on counts from SEN registers are very similar to those from the South East Thames Region study[10] (94 per 10 000 compared with 116.1 per 10 000, 95% CI 90.4–141.8). These authors took the decision to screen only the 'at-risk' population and assert that their estimate should be regarded as the minimum figure. Our results from screening the entire school-aged population support this assertion and highlights the reality that there are children with autism-spectrum conditions, notably children with high-functioning autism, who remain undetected in primary schools. These children may use strategies to mask their social and communication difficulties such as going to the computer room at playtime. They may be quiet and cooperative at school and not difficult to manage and therefore teachers may not be aware that they have difficulties. Primary schools in the UK are typically small and foster a supportive and nurturing environment. It may not be until these children move to secondary school that their true differences are revealed.

Cambridgeshire is not a nationally representative population since it has a higher proportion of higher social classes than the rest of the UK. Parents of children with known or suspected autism-spectrum conditions may migrate into areas where there are services available. Our study does not report on migration of families but given the level of services for and awareness of autism-spectrum conditions in Cambridgeshire, this remains a distinct possibility. Caution should therefore be employed in assuming that the figures reported here can be applied nationwide. Given the close parallels in results between the South East Thames Region study[10] and our study, it suggests regional differences are minimal, but it would be valuable to estimate prevalence in areas that are more broadly representative of the whole country.

Implications

Epidemiological research involving screening the school-age population for developmental conditions is not without difficulties. Our experience from this study and previous studies[47] has indicated response to surveys to be a major limitation. Although our final estimates may be built upon a selection of possible assumptions about the non-responding population, our most conservative estimate (assuming no cases of autism-spectrum conditions in the non-responders) is still nearly 12 times higher than the estimate in 1978.[9] Independent replication of this study is warranted, in particular to ascertain diagnostic

verification of parent-reported and SEN-register autism-spectrum condition diagnoses. Results from this study should be treated with caution because of the low response and the finding that the socioeconomic distribution of the population was not representative of the UK population. Notwithstanding this, as autism-spectrum conditions are being increasingly recognised, these studies suggest that appropriate services should plan to meet the needs of between 1–2% of the primary school-aged population.

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EXTRA CONTENT ONLINE

100 years ago

Themes: part 2

Henry R. Rollin

In this, the second of two contributions, Henry Rollin presents a digest of some of the themes explored in his long-running '100 years ago' series. A full-length article on this topic is available as an online supplement to this item.

Causation of mental illness – proven and alleged

Masturbation
Psychiatry has its own fashions. A good example was the one rampant at the beginning of the 20th century, when masturbation was considered as the cause of all evils, particularly of the neuroses and even, by others, of the psychoses.

Among those who firmly believed this absurdity was Lord Baden Powell, who founded the Boy Scout movement in 1908, and more surprisingly, by acknowledged leaders of the psychiatric profession, Henry Maudsley and even Sigmund Freud *lui-même*!

Syphilis proved as the cause of GPI
It is difficult today to appreciate the enormity of the scourge of general paralysis of the insane (GPI) 100 years ago. Statistically, it rated second to alcohol misuse as the cause of admissions to mental hospitals. But whereas, if treated early, alcoholism was recoverable, those suffering from GPI, *ab initio*, were doomed to die a wretched, lingering death.

But, although syphilis was suspected as the cause of GPI, it could not be confirmed until August von Wasserman (1866–1925), a German bacteriologist, developed a specific blood test (WR) in 1906.

Cannabis including hashish, marijuana, hemp and skunk
For centuries, the addiction to this group of closely allied potent drugs has been common in the Middle East, India and elsewhere – but the hard evidence of its grave consequences was not to be found until the report of Dr John Warnock (*Journal of Mental Science*, January 1903). He states that for the years 1896–1901, out of 2564 male patients admitted to the Egyptian Asylum at Cairo, 689 were attributed to the use of hashish (27%). He adds that the addiction is responsible for a substantial amount of crime.

Epilepsy
As recently as 1904, lingering doubts were expressed as to the precise causation of epilepsy. Thus, the *Lancet* (2 April 1904) published an extract from the *Journal of Nervous and Mental Diseases* in which Professor Allen M. Starr of New York writes that, 'the prevailing opinion is that epilepsy is usually, if not always, an organic disease.'

Neurasthenia
Professor Charles Dana's long account on neurasthenia in the *Boston Medical and Surgical Journal*, 1904, to which the *Lancet* (30 April 1904) devotes a page-long account, is so steeped in heavy sarcasm as to merit its reading *in extenso*.

Briefly, he alleges that in neurasthenia, 'the psyche has to be hit hard' and that, 'if all that is attributed to neurasthenia is cut away, about one half of the great national malady attributed to it in America is also cut away'.

Doctors *v.* lawyers

The antipathy between these two learned professions continues robust. For example, there is the ripe report (*Journal of Mental Science*, April 1889):

> 'Mr Justice Field in addition to treating the medical witness with studious rudeness, refused to receive their opinion as to the sanity of the prisoner. ''He could no more dive into a man's state of mind than I can'', was his final lacerating riposte.'

Acknowledgement

P.S. This is the last instalment of the regular column, 100 years ago, although occasional entries will appear in the *Journal* as extras.