Epidemiology of Autism Spectrum Disorders in Adults in the Community in England

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Context: To our knowledge, there is no published information on the epidemiology of autism spectrum disorders (ASDs) in adults. If the prevalence of autism is increasing, rates in older adults would be expected to be lower than rates among younger adults.

Objective: To estimate the prevalence and characteristics of adults with ASD living in the community in England.

Design: A stratified, multiphase random sample was used in the third national survey of psychiatric morbidity in adults in England in 2007. Survey data were weighted to take account of study design and nonresponse so that the results were representative of the household population.

Setting: General community (ie, private households) in England.

Participants: Adults (people 16 years or older).

Main Outcome Measures: Autism Diagnostic Observation Schedule, Module 4 in phase 2 validated against the Autism Diagnostic Interview–Revised and Diagnostic Interview for Social and Communication Disorders in phase 3. A 20-item subset of the Autism-Spectrum Quotient self-completion questionnaire was used in phase 1 to select respondents for phase 2. Respondents also provided information on sociodemographics and their use of mental health services.

Results: Of 7461 adult participants who provided a complete phase 1 interview, 618 completed phase 2 diagnostic assessments. The weighted prevalence of ASD in adults was estimated to be 9.8 per 1000 (95% confidence interval, 3.0-16.5). Prevalence was not related to the respondent’s age. Rates were higher in men, those without educational qualifications, and those living in rented social (government-financed) housing. There was no evidence of increased use of services for mental health problems.

Conclusions: Conducting epidemiologic research on ASD in adults is feasible. The prevalence of ASD in this population is similar to that found in children. The lack of an association with age is consistent with there having been no increase in prevalence and with its causes being temporally constant. Adults with ASD living in the community are socially disadvantaged and tend to be unrecognized.

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there is no information about community prevalence across the age range in that population. Adults in Great Britain who have responded to postal and online surveys13 stating that they have ASD are more often male (2:1), rarely 65 years or older, and rarely in full-time employment. They tend to have been given a diagnosis of high-functioning autism or Asperger syndrome, with only 1 in 5 in receipt of psychological or psychiatric services.

Cases of ASD in surveys of children have been identified using direct observation and collateral descriptions of behavior (from parents and teachers),5-7 techniques that are less feasible in adults. We used a multiple-phase design: an initial screening phase of adults in the community, a direct observation second phase, and developmental interviews of collateral informants in a third phase.

We hypothesized that, in the community, the rate of ASDs in early adulthood would be more likely to be male and disadvantaged socioeconomically and less likely to be receiving support from mental health services than adults with other mental disorders.

MEASURES

We used stepwise logistic regression to develop a 20-item subset of the 50-item AQ, using previously gathered diagnostic clinic and control data.13,14 The 20-item version (AQ-20) was administered to all phase 1 respondents to generate a probability of selection for the detailed phase 2 diagnostic assessment. Phase 1 respondents also completed questionnaires covering physical and mental health, socioeconomic factors, use of mental health services,14 and willingness to take part in further interviews. Predicted verbal IQ (V-IQ; range estimate, 70-130) was the only method for estimating IQ available in the 2007 Adult Psychiatric Morbidity Survey, although its validity in community cases of ASD is untested. National Centre for Social Research interviewers conducted fieldwork from October 2006 through December 2007. A few of the selected respondents were incapable of undertaking the interview alone because of mental or physical incapacity. For them, the option of a proxy interview with another member of the household or someone else who knew them well was available (Figure 1). The information collected was insufficient for selection probabilities to be calculated, and respondents interviewed by proxy were therefore ineligible for phase 2 interviews.

Phase 2 ASD assessments were based on the ADOS-4, a face-to-face clinical assessment of current behavior consistent with a diagnosis of ASD. It consists of tests termed presses that evaluate communication, reciprocal social interaction, creativity, imagination, and stereotyped and restricted interests. The ADOS-4 incorporates algorithms for ASD,21 applied to selected ADOS-4 ratings corresponding to DSM-IV22 criteria for pervasive developmental disorder. Phase 2 interviewers were experienced in psychological research and received an induc-
tion and training program, run by a senior research psychologist (J.S.), a psychiatrist (T.S.B.), and a qualified ADOS-4 trainer (F.S.). Training experience was gained through assessing adults living in the community, including students, and working age and older adults who had a clinician-determined diagnosis of an ASD such as Asperger syndrome. Interviewing in the field did not commence until the 4 interviewers achieved at least 90% agreement on ratings of jointly observed ADOS-4 examinations. During fieldwork, interviewees received supervision sessions and prepared ASD case vignette reports. They took part in debriefing after the interviews to add further contextual information.

A threshold of 10 or greater on the ADOS-4 total score is recommended for identifying cases of autism, provided it includes scores of at least 3 on the Communication domain and at least 6 on Reciprocal Social Interaction. To our knowledge, for the first time in a community sample and in older adults, we validated this threshold for determining a case of ASD using the ADOS-4, with 54 assessments carried out by the senior research psychologist in a third study phase (Figure 1). These assessments included developmental interviews with family members or other suitable informants of second-phase respondents, half of whom had a high probability of having ASD. The Autism Diagnostic Interview–Revised (ADI-R) and the Diagnostic Interview for Social and Communication Disorders (DISCO) were administered. The appropriateness of using a threshold of 10 or greater was tested using models based on predicting cases of ASD from these 2 tools (details of these assessments and of clinical consensus diagnoses will be reported separately).

ANALYSIS

Survey data were weighted to take account of study design and nonresponse so that the results were representative in terms of age, sex, region, and area characteristics of the household population 16 years or older in England. First, sample weights were applied to take account of the different probabilities of selecting respondents in different-sized households. Second, to reduce household nonresponse bias, a household-level weight was calculated from a logistic regression model using interviewer observation and area-level variables (using 2001 UK Census data) available for responding and nonresponding households. The nonresponse weight for each household was calculated as the inverse of the probability of response estimated from the model multiplied by the household’s selection weight. Finally, weights were applied using the techniques of calibration weighting based on age, sex, and region to weight the data to represent the structure of the national population, by taking account of differential nonresponse between regions and age × sex groups. The population control totals used were the Office for National Statistics 2006 midyear household population estimates. Phase 2 weights were designed to generate condition-specific phase 2 data sets representative of the population eligible for phase 2 by virtue of that particular condition. Combining the phase 2 weighted data with the phase 1 weighted data for the noneligible group thus gives data representative of the whole adult population. Because incomplete response could bias survey estimates, we investigated possible nonresponse bias: we compared the probability of ASD (phase 1 AQ-20 score) between geographic regions by regional response rate and by each respondent’s willingness to take further part in the survey.

Weighted prevalence estimates were determined using an ADOS-4 threshold of 10 or greater (PROC SURVEYFREQ, version 9.1; SAS Institute, Inc, Cary, North Carolina) and for comparison a range of thresholds from 7 or greater to 13 or greater. The distribution of AQ-20 and ADOS-4 scores was examined using histograms. The small number of people identified as having ASD (in terms of the number of ADOS-4 cases found) means that caution is required in interpreting the population distribution of ASD. Variation in prevalence of ASD by other characteristics was examined in univariable and multivariable weighted logistic regression models (PROC SURVEYLOGISTIC, version 9.1; SAS Institute, Inc) and by examining the predicted probability of being a case as a function of continuously measured characteristics (age and V-IQ). The sample for these analyses consisted of phase 1 respondents with a near zero probability of ASD (AQ-20 score < 5, classified as non-ASD cases) together with all respondents who completed a full ADOS-4 in phase 2. Phase 1 respondents with an AQ-20 score of 5 to 20 who were not administered a phase 2 assessment were excluded as unknowns and accounted for in the weighting.

RESULTS

Of the 13,171 households identified as potentially eligible in the Adult Psychiatric Morbidity Survey, 4,075 refused; 7,461 individuals in the households (56.6%) provided a complete phase 1 interview. Of these, 849 people were selected for phase 2 interviews; 62 refused and no contact was made with 157, leaving 630 participants (74.2%) who completed phase 2 assessments (Figure 1). Full ADOS-4 assessments were carried out in 618 participants. Nonresponse bias was investigated by comparing the proportion scoring 13 or greater on the AQ-20 in the 5 regions with the highest response rate and the 6 regions with the lowest response rate in phase 1: it was 1.1% and 1.2%, respectively; using weighted data, it was 1.1% and 1.3%. Refusal to take part by participants selected for a phase 2 interview was 24% overall: the proportion of those who refused and scored 13 or greater on the AQ-20 was 24.3% among individuals with an AQ-20 score of 0 to 12 and 23.3% among those with an AQ-20 score of 13 to 20. Neither comparison gave any indication that survey participation was associated with having ASD. The ADOS-4 threshold of 10 or greater for ASD was supported by models based on predicting cases of ASD from the phase 4 Diagnostic Interview for Social and Communication Disorders and Autism Diagnostic Interview–Revised developmental assessments (details will be reported separately).

Using the validated threshold of a score of 10 or greater on the ADOS-4 to indicate a case of ASD, we determined that the overall prevalence of ASD in the English population of individuals 16 years or older was 9.8 per 1000 population (95% confidence interval [CI], 3.0-16.5). Table 1 includes the unweighted and weighted numbers of cases and weighted estimates for ADOS-4 cutoffs from 7 or greater to 12 or greater. The estimated V-IQ of our ASD cases ranged from 70 (and less) to 100.

UNIVARIABLE MODELS

The rate of ASD among men (18.2 per 1000; 95% CI, 4.2-32.2) was much greater than among women (2.0 per 1000; 95% CI, 0.0-4.3). This difference was statistically significant in a weighted univariable logistic model (Table 2). Figure 2 depicts the association with age using the weighted prevalence of ASD according to the

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diagnostic ADOS-4 threshold of 10 or greater. The predicted probability of ASD suggested a gradual decrease with increasing years, although the trend was not significant (odds ratio, 0.99; 95% CI, 0.94-1.04; \( P = .55 \)); assuming that this is the true odds ratio, for every extra year of age, the odds of ASD would decrease by 1%. The lower limit of the 95% CI suggests a decrease in the odds of 6% with every increasing year of age. In a univariable model, the predicted probability of ASD (ADOS-4 ≥10) was inversely related to V-IQ score (odds ratio, 0.94; 95% CI, 0.87-0.99; \( P = .04 \)); for every unit increase in V-IQ score, the odds of ASD decreased by 6.0%.

Having ASD was significantly associated with living in accommodation rented from a social landlord (local authority or housing association) rather than from a private landlord or owned by the participant or other member of the household (Table 2). The presence of ASD was higher in participants without any educational qualifications than in those with university-level qualifications (Table 2).

The presence of ASD was significantly associated with being single (Table 2). A relative preponderance of ASD in more deprived local areas (wards) was close to being statistically significant (\( P = .06 \); Table 2). There was no overall association between equivalized household income and the presence of ASD; in participants living in households with the highest income, ASD was less frequent than among those with the lowest incomes, which was close to being statistically significant (\( P = .06 \); Table 2). No significant association was identified between household composition and ASD. People who did not know whether they received state benefits had higher odds of having ASD (Table 2); there was insufficient information to determine whether receiving benefits was associated with ASD. Among working-age participants (aged 16-64 years), we found no significant association with economic activity. We had insufficient data to evaluate

### Table 1. Weighted Cumulative Estimates of Respondents per 1000 Population for ADOS-4 Cut-offs

<table>
<thead>
<tr>
<th>ADOS-4 Cut-off</th>
<th>Unweighted Base (n = 2828)</th>
<th>Weighted Base (n = 7333)</th>
<th>Weighted Estimate Rate per 1000 Population (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>≥7</td>
<td>32</td>
<td>108</td>
<td>14.7 (7.0-22.5)</td>
</tr>
<tr>
<td>≥8</td>
<td>26</td>
<td>88</td>
<td>12.0 (4.9-19.1)</td>
</tr>
<tr>
<td>≥9</td>
<td>20</td>
<td>75</td>
<td>10.2 (3.4-17.0)</td>
</tr>
<tr>
<td>≥10</td>
<td>19</td>
<td>72</td>
<td>9.8 (3.0-16.5)</td>
</tr>
<tr>
<td>≥11</td>
<td>16</td>
<td>65</td>
<td>8.9 (2.2-15.5)</td>
</tr>
<tr>
<td>≥12</td>
<td>12</td>
<td>47</td>
<td>6.4 (0.6-12.3)</td>
</tr>
<tr>
<td>≥13</td>
<td>10</td>
<td>44</td>
<td>6.0 (0.2-11.8)</td>
</tr>
</tbody>
</table>

Abbreviations: ADOS-4, Autism Diagnostic Observation Schedule, Module 4; CI, confidence interval.

*a* A threshold of 10 or greater on the ADOS-4 total score is recommended for a case of autism, including scores of at least 3 on the Communication domain and at least 6 on Reciprocal Social Interaction.

### Table 2. Univariable Candidate Predictors of Presence of ASD

<table>
<thead>
<tr>
<th>Univariable Predictor</th>
<th>Overall ( P ) Value</th>
<th>Comparison Group vs Reference Group</th>
<th>OR (95% CI)</th>
<th>( P ) Value for Selected Comparison</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td>.001</td>
<td>Male vs female</td>
<td>9.14 (2.37-35.15)</td>
<td>.001</td>
</tr>
<tr>
<td>Marital status</td>
<td>.02</td>
<td>Single vs not single</td>
<td>4.70 (1.22-18.02)</td>
<td>.02</td>
</tr>
<tr>
<td>Tenure</td>
<td>.002</td>
<td>Social vs owner</td>
<td>11.23 (2.86-43.48)</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Equivalized household income</td>
<td>.17</td>
<td>Low vs high</td>
<td>5.60 (0.90-34.62)</td>
<td>.36</td>
</tr>
<tr>
<td>Highest educational qualification</td>
<td>.07</td>
<td>None vs degree/HND, college, university</td>
<td>11.63 (2.33-58.83)</td>
<td>.003</td>
</tr>
<tr>
<td>Employment status</td>
<td>.88</td>
<td>Out of work vs in work</td>
<td>1.86 (0.16-21.28)</td>
<td>.62</td>
</tr>
<tr>
<td>Receipt of benefits</td>
<td>.04</td>
<td>Does not know vs none</td>
<td>13.33 (1.59-111.11)</td>
<td>.02</td>
</tr>
<tr>
<td>Index of Multiple Deprivation</td>
<td>.06</td>
<td>High vs medium vs lowest, ordinal</td>
<td>2.34 (0.96-5.69)</td>
<td>.06</td>
</tr>
<tr>
<td>Verbal IQ, NART</td>
<td>.04</td>
<td>Continuous</td>
<td>0.94 (0.87-0.998)</td>
<td>.04</td>
</tr>
<tr>
<td>Age</td>
<td>.55</td>
<td>Continuous</td>
<td>0.99 (0.94-1.04)</td>
<td>.55</td>
</tr>
</tbody>
</table>

Abbreviations: ADOS-4, Autism Diagnostic Observation Schedule, Module 4; ASD, autism spectrum disorder; AQ-20, 20-item Autism-Spectrum Quotient; CI, confidence interval; GCSE, General Certificate of Secondary Education; HND, Higher National Diploma; NART, National Adult Reading Test; OR, odds ratio.

*a* For total scores on the ADOS-4 with a threshold of 10 or greater (\( n = 2854 \)). The reference category for OR reporting is always the second category. For example, men have 9.14 times the odds of ASD than women.

*b* Models in phase 1 carried out on respondents with a low probability of having ASD (AQ-20 <5) and on all respondents who completed ADOS-4 in phase 2.

*c* Household income was established by means of a show-card on which banded incomes were presented. Equivalized income is adjusted to take account of the number of people living in the household. To derive this, each household member is given a score depending, for adults, on the number of adults cohabiting or not cohabitating and, for dependent children, their age. The total household income is divided by the sum of the scores to provide the measure of equivalized household income. Respondents were then allocated to the equivalized household income quintile to which their household had been allocated.

*d* Respondents who reported foreign qualifications or qualifications that could not be classified were excluded.

*e* Receipt of any benefit other than state pensions, child benefit, Working Tax Credits, or maternity-related benefits. Social fund grants and housing benefits were included.

*f* The Index of Multiple Deprivation 2007 combines a number of indicators chosen to cover a range of economic, social, and housing issues into a single deprivation score for each small area in England. This allows each area to be ranked relative to one another according to its level of deprivation in the form of an ordinal variable.

*g* An estimate of verbal IQ was derived using the NART score. Respondents who did not speak English as their first language, who had eyesight problems, or who stated that they had dyslexia were excluded from the base.
associations with ethnic groups. Each analysis using the ADOS-4 threshold of 10 or greater in Table 2 was repeated with the cut-off of 7 or greater. The statistically significant associations for sex and tenancy for an ADOS-4 threshold of 10 or greater were also found when the threshold was 7 or greater; those for other associations were also in the same direction but no longer statistically significant.

Because most (15 of 19) of the phase 2 cases with an ADOS-4 threshold of 10 or greater were in male participants, the weighted univariable logistic model (Table 2, males and females combined) was repeated in males only. The findings were unaltered.

**MULTIVARIABLE MODELING**

Multivariable backward stepwise logistic modeling was performed using the 8 most significant and borderline significant univariable predictors listed in Table 2 (analysis conducted on both sexes), producing 3 significant predictors after removal of nonsignificant variables with the use of backward selection (Table 3). Men had nearly 9 times the odds of having an ASD diagnosis compared with women (P = .002). For every unit increase in the level of education, the odds of ASD decreased by 55% (P = .049). Those in social housing had a significantly higher odds of having ASD compared with those who owned their home (P = .03). Index of Multiple Deprivation, single marital status, receipt of welfare benefits, household income, and V-IQ were not associated (Table 3). Finally, age (continuous) was added to the model. However, its inclusion did not improve the fit of the model (odds ratio, 0.98; 95% CI, 0.94-1.02; P = .36).

**USE OF SERVICES**

Service use for mental or emotional problems was compared between participants with and without ASD. These data are not shown in a table because the base number for people with ASD was too small to make meaningful statistical comparisons (19 cases were identified in the 2007 Adult Psychiatric Morbidity Survey sample). Nevertheless, there was no evidence of increased use of services for mental or emotional problems by people with ASD in the preceding month or year. None of the cases found in this study had previously been given a formal autism assessment or diagnosis.

**COMMENT**

Autism spectrum disorder affects approximately 1% of the adult English household population. There was no evidence of a statistically significant reduction in prevalence of ASDs as a function of age. Prevalence was greatest in men, in those living in social housing, and in those with the lowest educational qualifications. Adults with ASD appear to be largely unrecognized. To our knowledge, there are no previous systematic community surveys of adults with which to compare these findings.

The survey was based on the most validated investigator-rated diagnostic instruments available for study-

![Figure 2. Predicted values of autism spectrum disorder (ASD) by age. P value for age as a continuous predictor of ASD (P=.55, using the recommended score threshold of 10 or greater on the Autism Diagnostic Observation Schedule, Module 4.](image)

### Table 3. Weighted Multivariable Model Candidate Predictors of Presence of Autism Spectrum Disorder

<table>
<thead>
<tr>
<th>Predictor</th>
<th>OR (95% CI)</th>
<th>P Value for Specific Comparison</th>
<th>P Value Overall</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Male vs female</td>
<td>8.62 (2.2-34.5)</td>
<td>.002</td>
<td>.002</td>
</tr>
<tr>
<td>Educational level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Continuous</td>
<td>0.45 (0.21-0.99)</td>
<td>.049</td>
<td></td>
</tr>
<tr>
<td>Housing tenure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Social vs owner</td>
<td>6.1 (1.7-21.7)</td>
<td>.03</td>
<td></td>
</tr>
<tr>
<td>Social vs private</td>
<td>2.5 (0.4-15.1)</td>
<td>.98</td>
<td></td>
</tr>
</tbody>
</table>

Abbreviations: CI, confidence interval; OR, odds ratio.

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pants. Sensitivity analyses showed no evidence of a nonresponse bias; reluctance to cooperate was not associated with a higher phase 1 AQ-20 score. This finding is supported by recent research showing that nonresponse rate alone is a weak predictor of nonresponse bias and by recent studies suggesting that changes in nonresponse rates do not necessarily alter survey estimates. Furthermore, the phase 2 weighting took account of variation in response rate by phase 1 AQ-20 score, age, and sex. Bias in prevalence estimation can be eliminated if an assumption of missingness at random within these adjustment cells is justified. In a missingness-at-random situation, missingness depends on demographic or other characteristics that can be adjusted for using weighting. If, after such adjustment has been made, missingness is not related to the survey outcome, missing data can be said to be missing at random. Given our sensitivity analyses and the absence of any other information to the contrary, it is plausible that within age, sex, region, and AQ-20 score groups (the variables upon which our weighting was based), our missing data situation approximates reasonably well to missingness at random. We found nothing in the literature on nonresponse bias pertaining to ASD specifically; nonresponse has been linked to psycing in the literature on nonresponse bias pertaining to monably well to missingness at random. We found noth-
vices is of potential public health importance. This is in a country with well-established social, educational, welfare, and health care services funded from taxation. Research is also needed in lower-income countries where clinical experience suggests that ASD is prevalent and disabling. Participants with ASDs were less likely to know about a key aspect of their financial circumstances, namely, whether they are receiving state financial benefits (Table 2). This is in line with the clinical observation that many people with ASD are ill equipped to manage their finances. Previous work\(^1\)\(^2\) shows that adults with mental health disorders receive more attention from services because these problems are recognized needs. However, we found no statistically significant increase in use of the services among adults with ASD. The cases identified in this survey were apparently not clinically recognized; the underrecognition of ASDs was also apparent in a recent national audit\(^6\) of support for more able adults with autism from local government and the national health service in England. This audit also makes a reasoned economic argument for increasing the identification of adults with ASD and for supporting them to obtain and maintain appropriate paid employment. The characteristics of our community survey cases appear to differ from those of adults who have responded to postal and online surveys stating that they have an ASD,\(^7\)\(^8\) emphasizing the importance of systematic case finding for public health information. Formal comparison of community and clinically diagnosed cases is not yet possible. However, it would appear that cases are often underdiagnosed in elderly individuals, those with lower levels of functioning, those in paid employment, and men.

There are no effective medical treatments for ASD, particularly in adulthood. Adults with ASD have enduring problems with communication and social understanding. However, social care services are being developed to support them, based on the principle that staff recognize and accept the presence of the condition and learn how to understand and communicate with those who have it. This might, for example, improve access to sustained paid employment.\(^9\) In our clinical experience, providing this sort of social care to adults with a diagnosis of ASD leads to improvements in quality of life and reductions in the inappropriate use of high-cost hospital services.

To our knowledge, we have demonstrated for the first time in the general population that the rate of ASD is not significantly associated with age, suggesting that the causes of autism are temporally constant. A great deal more research should be directed at the epidemiology and care of adults with this condition.

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Additional Contributions: Acknowledgment for the advice and support of groups and individuals can be found elsewhere.\(^1\)

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