Data supplement to Brugha et al. Epidemiology of autism in adults across age groups and ability levels. Br J Psychiatry doi: 10.1192/bjp.bp.115.174649

Online supplement DS1: Sampling details of the Intellectual Disability Case Register study (IDCR)

In order to achieve a complete sample of adults in England two groups of adults not considered in the Adult Psychiatric Morbidity Survey (APMS) by design needed to be identified: those living in a private household but incapable of taking part in a survey interview because of intellectual disability, and those not included in the APMS sample due to being resident in a communal care establishment (or 'institution'). The IDCR was based on samples drawn from three registers of adults with intellectual disability in England, located in Leicestershire, Lambeth and Sheffield, although the achieved sample in Sheffield was very small. The adult prevalence of intellectual disability, defined by significant intellectual impairment (WHO definition) with adaptive skill deficits, using the registers at the three sites was within the expected range (4.9, 4.3 and 5.4/ 1000 of the population of Leicestershire, Lambeth and Sheffield respectively (National Statistics (1)). These registers have been used extensively for research (2) (3) (4).

A random sample of individuals on the registers from private households with addresses eligible for the APMS, was selected, stratified by age, sex and type of residence. Participants were then excluded if they were judged to have decision-making capacity to consent and sufficient ability to participate in the APMS. Interviewers initially made this judgement over the telephone and again when visiting the potential participant in their own home (if they had not already been excluded following the initial telephone conversation). The study also included residents of communal care establishments, comprising any domestic group setting with an intrinsic care function, such as a residential home or nursing home. For Leicestershire and Sheffield, the IDCR study adopted a two stage sampling design for communal care establishments. The first stage involved randomly selecting establishments

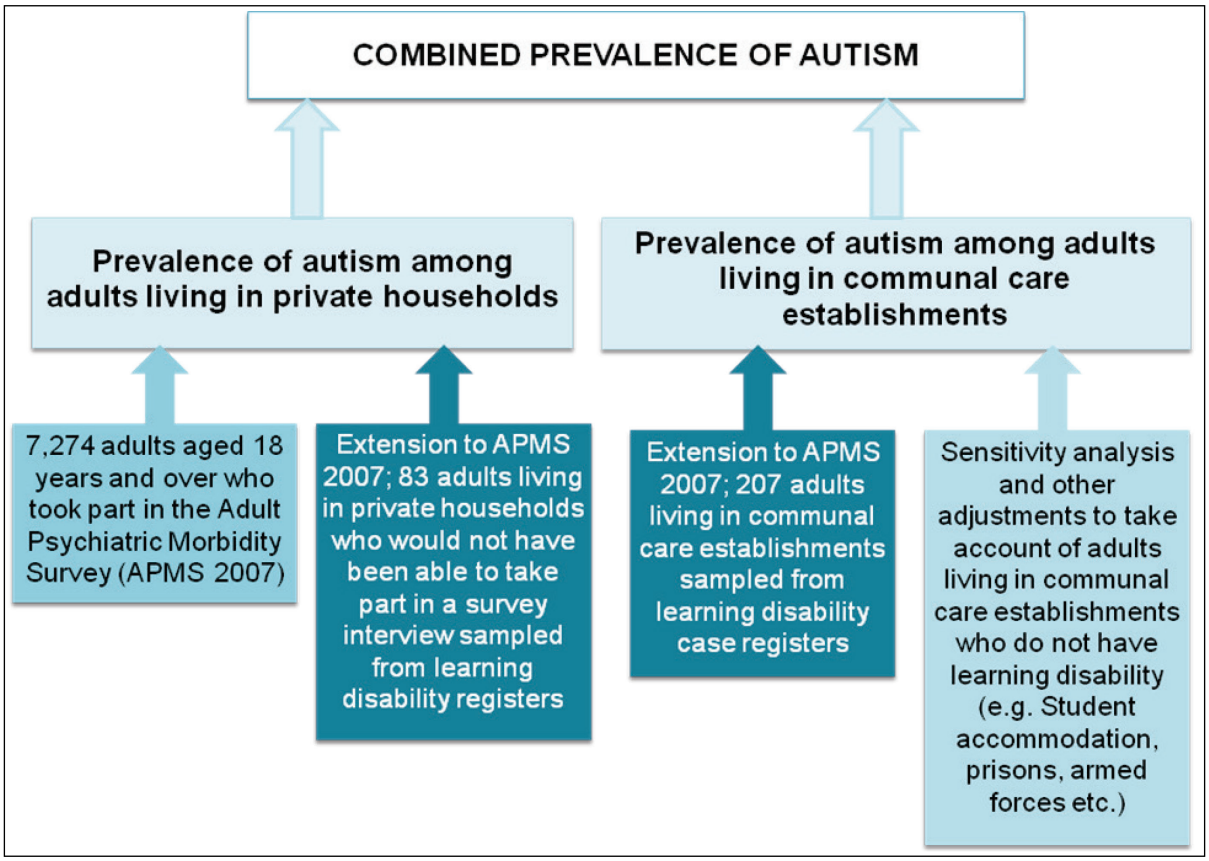
with four or more residents, with selection probabilities proportional to the number of eligible residents. The second stage involved randomly selecting four participants from each of the chosen communal care establishments stratified by sex and age. For Lambeth, which had fewer communal care establishments, all establishments with 3 or more residents were chosen and all residents were sampled.

Consent was obtained following the English mental capacity act, 2005, for adults who did not have decision making capacity to consent to participate in the research. We excluded participants who could not speak English and had non-English speaking carers. Sampled participants, carers or managers were sent a letter of invitation, with information about the study. Participants in Leicestershire were telephoned by the research team ('opt-out consent procedure'); carers and participants in Lambeth contacted the research team only if they wished to take part in the study ('opt-in consent procedure').

Combining the APMS and IDCR Samples for Analysis

In the IDCR study the primary sampling unit was the communal care establishment or, in the case of those in private households, the individual. In the APMS the primary sampling units were individual or small groups of postcode sectors. The datasets were appended, giving a total of 268 strata, 260 by socioeconomic status within region from the APMS and 8 by age, sex and residence (communal establishment or private household) from the IDCR study. APMS data were weighted to account for the complex sampling design, including two-stage sampling for autism as described elsewhere (5). The combined data (figure) were weighted to represent the English population by age, sex, intellectual disability and type of residence. Post-stratification weights were calculated using data from official statistics, including the mid-year population estimates derived from the 2001 census and data on intellectual disability from the Social Services Activity Statistics and the case registers. Full details are given in a data quality and methodology report (6).

Figure: Illustrating the calculation of the combined autism prevalence estimate



Online supplement DS2 Possible limitations in the comparability of our assessment of intellectual disability across the APMS and IDCR samples and in the assessment of autism in the IDCR sample

Both ADOS-Mod1 and ADOS-Mod4 have been carefully validated in the study samples with the aim of achieving comparable measurement across intellectual ability levels. There is some concern that autism assessment in the intellectual disability study with the ADOS-Mod1 achieved only moderate sensitivity on validation. Assessors suggested that this may be due to assessment tasks that are age-inappropriate for the adult population, for example using bubbles, dolls and toy cars. It is possible that missed cases at older ages may

account for the decline in prevalence of autism with age found in the intellectual disability study; alternatively, there may be an earlier age of death in the group with both autism and intellectual disability (14;15). It is also possible that older people may do better in assessments having adapted to their symptoms.

Online Supplement DS3: Examination of Potential for Selection Bias in the IDCR

The 276 adults who were assessed for autism had a similar age structure to the non-participants from the case registers, but with some oversampling of women (Table DS1). Further information was recorded for 97% (n=3080) of those on the Leicestershire case register only. This included a measure of autistic traits previously validated against clinical diagnoses (16).

The traits were poor quality of social interaction, lack of empathy, simple stereotypies and elaborate routine, usually carer-reported, but self-reported for a small minority who were interviewed for the case register on their own.

In the Leicestershire sample, participants and non-participants in communal care establishments had similar intellectual disability severity, ethnicity, epilepsy and autistic trait profiles (Table DS1). Participants in private households were younger, had more severe intellectual disability and greater autism, prevalence than non-participants. On restricting the sample to adults with moderate to profound ID, the prevalence of epilepsy was marginally higher among participants (30.6% and 24.3% for participants and non-participants respectively) and the mean number of autistic traits was similar (0.72 and 0.74 for participants and non-participants respectively).

Prevalence of two or more autistic traits in communal care establishments was 22.6% in men and 21.4% in women, compared to 14.4% and 9.9% respectively in the private household population. In the Leicestershire Communal Care Establishment sample, men with two or more autistic traits were somewhat oversampled compared to those with no or one trait, while the proportion of women with two or more traits was identical in participants

and non-participants (Table DS2). In the private household sample numbers were too small to assess possible non-response bias. For the unexpected number of female autism cases in the intellectual disability population to be artefactual, would require considerable under-sampling of autistic men and oversampling of autistic women in the IDCR achieved sample. There is no evidence of this in the comparison with the Leicestershire populations (Table DS3), although assessment was limited by small numbers in the private household sample. While there is some potential for selection bias on the estimate of autism prevalence in the IDCR study private household sample, bias sufficient to undermine our finding of an interaction between sex and intellectual disability on the prevalence of autism is implausible.

The IDCR sample is drawn largely from Leicestershire, a population that compares closely to the English population on socio-demographic characteristics (Table DS2), with the exception of greater numbers of South Asian ethnicity, mainly resident in the City of Leicester. The proportion of school pupils with an official statement of special education needs, and the proportion in special (education need) schools, is very similar to England as a whole, suggesting that a honeypot effect is unlikely. There are approximately 0.5m people living in the City of Leicester and surrounding built up area, 0.3m living in other urban areas (market towns or other conurbations with population>10,000), and 0.2m living in rural areas. Leicestershire lacks a major conurbation, which may be relevant given evidence from the Leicestershire case register that autism is more prevalent in rural areas (7), but our sample did include limited numbers from the London Borough of Lambeth.

In conclusion, the 'opt-in' consent procedure in Lambeth and Sheffield, proved an almost insuperable barrier to recruitment, meaning that the IDCR sample is largely based upon the Leicestershire adult population case register. The Communal Establishment population in Leicestershire was successfully surveyed, with 64% of establishments and 69% of eligible individuals approached taking part. However, the response rate in private households in Leicestershire was low at 35%. Difficulties in recruiting adults with intellectual disability into research studies have been well documented (8-10). Many refusals were because carers

were worn out with a lifetime of caring. However, studies of autism in adults are very rare, and the response rate is consistent with others (11;12). Only, the Glasgow cohort (13) achieved a response rate of 70.6%, based on exceptional quality of routine data coding, and collaborative working between the clinical team and research team in providing information and consenting, but it did not have a validated systematic diagnostic assessment.

Additional References

(1) National Statistics. Mid-year population statistics. Durham: NOMIS; 2010. http://webarchive.nationalarchives.gov.uk/20160105160709/http://ons.gov.uk/ons/rel/pop-estimate/population-estimates-for-uk--england-and-wales--scotland-and-northern-ireland/mid-2010-population-estimates/index.html

(2) Roeleveld N, Zielhuis GA, Gabreels F. The prevalence of mental retardation: a critical review of recent literature. Dev Med Child Neurol 1997 Feb;39(2):125-32.

(3) Institute of Public Care. Estimating the prevalence of severe learning disability in adults (working paper). Oxford: Institute of Public Care via Projecting Adult Needs and Service Information (PANSI); 2009.

(4) Parrott R, Emerson E, Hatton C, Wolstenholme J. Future demand for residential provision for people with learning disabilities. Manchester: Hester Adrian Research Centre, University of Manchester; 1997.

(5) Brugha TS, McManus S, Bankart J, Scott F, Purdon S, Smith J, et al. Epidemiology of autism spectrum disorders in adults in the community in England. Arch Gen Psychiatry 2011 May;68(5):459-65.

(6) Brugha T, Cooper SA, McManus S, Purdon S, Scott FJ, Spiers NA, et al. Estimating the Prevalence of Autism Spectrum Conditions in Adults: Data quality and methodology document. Leeds: The NHS Information Centre; 2012 Jan 31.

(7) Kiani R, Tyrer F, Hodgson A, Berkin N, Bhaumik S. Urban-rural differences in the nature and prevalence of mental ill-health in adults with intellectual disabilities. J Intellect Disabil Res 2013 Feb;57(2):119-27.

(8) Evenhuis H, van SJ, Vink M, Weerdenburg C, van ZB, Stilma J. Obstacles in large-scale epidemiological assessment of sensory impairments in a Dutch population with intellectual disabilities. J Intellect Disabil Res 2004 Nov;48(Pt 8):708-18.

(9) Lacono T. Issues of informed consent in conducting medical research involving people with intellectual disabilities. Journal of Applied Research in Intellectual Disabilities 2003;16:41-51.

(10) Oliver PC, Piachaud J, Done J, Regan A, Cooray S, Tyrer P. Difficulties in conducting a randomized controlled trial of health service interventions in intellectual disability: implications for evidence-based practice. J Intellect Disabil Res 2002 May;46(Pt 4):340-5.

(11) Bhaumik S, Tyrer FC, McGrother C, Ganghadaran SK. Psychiatric service use and psychiatric disorders in adults with intellectual disability. J Intellect Disabil Res 2008 Nov;52(11):986-95.

(12) McManus S, Meltzer H, Brugha T, Bebbington P, Jenkins R. Adult Psychiatric Morbidity in England, 2007. Results of a household survey. London: The NHS Information Centre for health and social care; 2009.

(13) Cooper SA, Smiley E, Morrison J, Williamson A, Allan L. Mental ill-health in adults with intellectual disabilities: prevalence and associated factors. Br J Psychiatry 2007 Jan;190:27-35.

(14) Gillberg C, Billstedt E, Sundh V, Gillberg IC. Mortality in autism: a prospective longitudinal community-based study. J Autism Dev Disord 2010;40(3):352-7.

(15) Bilder D, Botts EL, Smith KR, Pimentel R, Farley M, Viskochil J, et al. Excess mortality and causes of death in autism spectrum disorders: a follow up of the 1980s Utah/UCLA autism epidemiologic study. J Autism Dev Disord 2013 May;43(5):1196-204.

(16) Bhaumik S, Tyrer F, Barrett M, Tin N, McGrother CW, Kiani R. The relationship between carers' report of autistic traits and clinical diagnoses of autism spectrum disorders in adults with intellectual disability. Res Dev Disabil 2010 May-Jun;31(3):705-12

Table DS1. Comparison of Case Register Characteristics between Participants and Non-Participants, by residence and setting

	Participants with an autism assessment		Non-participants enrolled on case registers when sampled for IDCR	
Communal care establishments				
All	**(N=197)**		**(N=1697)**	
Age (when sampled)	47.4±13.7		49.5±14.9	
Sex				
Male	103	(52.3)	960	(56.6)
Leicestershire only	**(N=163)**		**(N=886)**	
Autistic traits[a]				
≥2 traits	40	(24.5)	188	(21.2)
≤1 trait	121	(74.2)	683	(77.1)
Autistic traits missing	2	(1.2)	15	(1.7)
Ethnic group				
White	147	(90.2)	794	(89.6)
South Asian	14	(8.6)	47	(5.3)
Other / Not known	2	(1.2)	45	(5.1)
Intellectual Disability Severity[b]				
Profound	42	(25.8)	269	(30.4)
Severe	61	(37.4)	276	(31.2)
Moderate	20	(12.3)	132	(14.9)
Mild/borderline	31	(19.0)	128	(14.4)
Not known	9	(5.5)	81	(9.1)
Epilepsy				
Present	41	(25.2)	224	(25.3)
Absent	110	(67.5)	574	(64.8)
Not known	12	(7.4)	88	(9.9)
Private households				
All	**(N=79)**		**(N=4444)**	
Age (when sampled)	36.0±14.1		38.0±14.5	
Sex				
Male	41	(51.9)	2551	(57.4)
Leicestershire only	**(N=74)**		**(N=2020)**	
Autistic traits[a]				
≥2 traits	8	(10.8)	246	(12.2)
≤1 trait	63	(85.1)	1731	(85.7)
Missing	3	(4.1)	43	(2.1)
Ethnic group				
White	53	(71.6)	1490	(73.8)
South Asian	15	(20.3)	385	(19.1)
Other / Not known	6	(8.1)	145	(7.2)
Intellectual Disability Severity[b]				
Profound	22	(28.7)	337	(16.7)
Severe	29	(39.2)	532	(26.3)
Moderate	11	(14.9)	473	(23.4)
Mild/borderline	6	(8.1)	466	(23.1)
Not known	6	(8.1)	212	(10.5)
Epilepsy[c]				
Present	23	(31.1)	393	(19.5)
Absent	47	(63.5)	1372	(67.9)
Not known	4	(5.4)	255	(12.6)

Plus-minus values are means±SD

a. Poor quality of social interaction, limited empathy, presence of elaborate routines and presence of stereotypies (Bhaumik 2010; Holmes et al. 1982)

b. As measured using the Leicestershire ID Scale (Tyrer et al. 2008)

c. Self- or carer-reported epilepsy or fits since age 16.

Table DS2. Comparison of Leicestershire Case Register Characteristics between Participants and Non-Participants by Sex.

	Participants with an autism assessment		Non-participants enrolled on case registers when sampled for IDCR	
Communal care establishments				
Males	**(N=92)**		**(N=530)**	
Autistic traits†				
≥2 traits	25	(27.2)	113	(21.3)
≤1 trait	65	(70.7)	409	(77.2)
Missing	2	(2.2)	8	(1.5)
Intellectual Disability Severity*				
Profound				
Severe				
Moderate				
Mild/borderline				
Not known				
Epilepsy				
Present				
Absent				
Not known				
Females	**(N=71)**		**(N=356)**	
Autistic traits†				
≥2 traits	15	(21.1)	75	(21.1)
≤1 trait	56	(78.9)	274	(77.0)
Missing	0	0	7	(2.0)
Intellectual Disability Severity*				
Profound				
Severe				
Moderate				
Mild/borderline				
Not known				
Epilepsy				
Present				
Absent				
Not known				
Private Households				
Males	**(N=38)**		**(N=1122)**	
Autistic traits†				
≥2 traits	3	7.9	160	14.3
≤1 trait	33	86.8	936	83.4
Missing	2	5.3	26	2.3
Females	**(N=36)**		**(N=898)**	
Autistic traits†				
≥2 traits	5	13.9	86	9.6
≤1 trait	30	83.3	795	88.5
Missing	1	2.8	17	1.2

* As measured using the Leicestershire ID Scale (Tyrer et al. 2008)

† Poor quality of social interaction, limited empathy, presence of elaborate routines and presence of stereotypies (Bhaumik 2010; Holmes et al. 1982)

Table DS3. Leicestershire and England: Sociodemographic Characteristics and Special Educational Needs (2011 Census).		
Characteristic	**Leicestershire**	**England**
Usual resident population	**(%,N=1017697)**	**(%,N=53,012,456)**
Age – yr		
0 to 15	19.0	18.9
16 to 44	39.7	39.4
45 to 64	25.5	25.4
65 and over	15.8	16.3
Sex		
Male	49.4	49.2
Ethnic group		
White	78.4	85.4
South Asian	16.1	7.8
Black/African/Caribbean/Black British	2.4	3.5
Other/mixed	3.1	3.3
Geography		
Urban (built-up area >10,000 inhabitants)	77.9	82.4
Usual resident population aged 16 years and over	**(%,N=824,351)**	**(%,N=42,989,620)**
Highest Educational Qualification		
None	24	22.5
GCSE or equivalent *,	27.9	28.5
Post-school†	42.2	43.4
Other ‡	6	5.7
School Pupils §	**(%,N=156,446)**	**(%,N=8,123,865)**
With official statement of specia need	2.7	2.8
In special school	1.0	1.1

*, School-based, usually taken at age 16

† Includes apprenticeship

‡ includes non-UK and some other vocational qualifications

§ source: https://www.gov.uk/government/publications/special-educational-needs-in-england-january-2011

Table DS4: Sample characteristics.[a]

Characteristic	Moderate to profound intellectual disability	No or mild/borderline intellectual disability	
	IDCR (*n*=217)	IDCR (*n*=47)	APMS (*n*=7274)
Gender, *n* (%)			
Male	121 (55.8)	19 (40.4)	3130 (43.0)
Female	96 (44.2)	28 (59.6)	4144 (57.0)
Age group			
18–29	38 (17.5)	13 (27.7)	921 (12.7)
30–44	62 (28.6)	18 (38.3)	1966 (27.0)
45–64	97 (44.7)	10 (21.3)	2409 (33.1)
65+	20 (9.2)	6 (12.8)	1978 (27.2)
Ethnic group, *n* (%)			
White	176 (81.1)	42 (89.4)	6700 (92.1)
South Asian	29 (13.4)	2 (4.3)	185 (2.5)
Black	8 (3.7)	0	191 (2.6)
Other/missing	4 (1.8)	3 (6.4)	198 (2.7)
Residence			
Private household	68 (31.3)	9 (19.2)	-
Communal establishment	149 (68.7)	38 (80.9)	-
Intellectual ability, *n* (%)[b]			
Profound intellectual disability	125 (57.6)	-	-
Severe intellectual disability	58 (26.7)	-	-
Moderate intellectual disability	34 (15.7)	-	-
Mild/borderline intellectual disability	-	47 (100)	-
IQ 70–85	-	-	1006 (13.8)
IQ 86–100	-	-	1829 (25.1)
IQ 101+	-	-	3916 (53.8)
IQ not assessed	-	-	523 (7.2)
Activities of daily living (ADL)			
ADL difficulties, median (IQR)[c]	7 (7, 7)	5 (4, 7)	0 (0, 1)
ADL with a lot of difficulty, median (IQR)	6 (4, 7)	2 (0, 3)	0 (0, 0)

Participants with missing data on ADLs, *n* (%)	13 (6.0)	8 (17.0)	18 (0.2)
Mobility, *n* (%)			
No difficulty	19 (8.8)	20 (42.6)	6253 (86.0)
Some difficulty	66 (30.4)	18 (38.3)	657 (9.0)
A lot of difficulty	132 (60.8)	9 (19.1)	364 (5.0)
Work, *n* (%)			
Never in paid work	185 (85.3)	30 (63.8)	230 (3.2)
Ever in paid work	10 (4.6)	11 (23.4)	6975 (95.9)
Missing	22 (10.1)	6 (12.8)	69 (0.9)

a. This is a more detailed version of Table 1 in the main text.

b. Classified using the Vineland II caregiver rating form[26] for the Intellectual Disability Case Register (IDCR) sample, and the National Adult Reading Test for Adult Psychiatric Morbidity Survey (APMS) sample. 12 adults from the IDCR study are excluded because they could not be classified.

c. Difficulty with seven ADL including personal care, getting out and about and using transport, medical care, household activities, practical activities, paperwork and managing money.