BJPsych | The British Journal of Psychiatry (2010) 196, 274–281. doi: 10.1192/bjp.bp.109.065490

Autism, ethnicity and maternal immigration

D. V. Keen, F. D. Reid and D. Arnone

Background
A growing number of European studies, particularly from Nordic countries, suggest an increased frequency of autism in children of immigrant parents. In contrast, North American studies tend to conclude that neither maternal ethnicity nor immigrant status are related to the rate of autism-spectrum disorders.

Aims
To examine the hypotheses that maternal ethnicity and/or immigration are linked to the rate of childhood autism-spectrum disorders.

Method
Retrospective case-note analysis of all 428 children diagnosed with autism-spectrum disorders presenting to the child development services in two centres during a 6-year period.

Results
Mothers born outside Europe had a significantly higher risk of having a child with an autism-spectrum disorder compared with those born in the UK, with the highest risk observed for the Caribbean group (relative risks (RRs) in the two centres: RR = 10.01, 95% CI 5.53–18.1 and RR = 8.89, 95% CI 5.08–15.5). Mothers of Black ethnicity had a significantly higher risk compared with White mothers (RR = 8.28, 95% CI 5.41–12.7 and RR = 3.84, 95% CI 2.93–5.02). Analysis of ethnicity and immigration factors together suggests the increased risk is predominately related to immigration.

Conclusions
Maternal immigration is associated with substantial increased risk of autism-spectrum disorders with differential risk according to different region of birth and possibly ethnicity.

Declaration of interest
None.

Autism-spectrum disorders, characterised by the presence of a triad of impairment of social cognition, communication and imagination, are considered to be the most common of the severe developmental disabilities. The rate of diagnosis has increased substantially with a recent estimated prevalence over 1%.[1] However, it is unclear whether this higher prevalence represents a true increase or could be attributed to changes in diagnostic practices and complex issues relating to service provision.[1–3]

The aetiology of autism-spectrum disorders is now largely considered to be multifactorial. Although genetic factors clearly play an important role, genetic study reveals an increasingly complex picture[4] and no unifying processes have been established[5] or alleged cause empirically supported.[1] Of possible risk factors, some specific environmental factors operating at the intrauterine level such as proximity to pesticides[6] and adverse perinatal events such as growth restriction and newborn hypoxia would appear to be of significance.[7–10]

There is an increasing literature supporting the role of advancing paternal and maternal age, although data for the latter are possibly inconsistent,[9–13] with a greater than twofold increase in risk with each 10-year increase in paternal age.[9] It has been suggested that first-born offspring of two older parents have a threefold risk of autism-spectrum disorders compared with younger siblings.[12]

Other social and environmental factors may also have a possible role in fuelling the increased prevalence and merit serious consideration. For example, the risk of autism appears to be associated with urbanisation.[11,14] Political and economic influences on patterns of population immigration and ethnic diversity have an increasingly important impact on society, with resultant implications for patterns of health and disease as well as for service access and provision. One recognised association with immigration is the substantially increased risk of schizophrenia in immigrants, which is not solely accounted for by psychosocial explanations and appears to be independent of genetic vulnerability, ethnic group or country of origin.[15]

Over the past 30 years or so there have been sporadic reports, initially of small populations or clinic samples, of an increased frequency of autism in children of immigrant parents, leading to the suggestion that immigration may be a factor contributing to the real rise in the prevalence of autism.[16] One of the first published reports describes a disproportionate number (21–29%) of children with infantile autism born to Greek and German parents emigrating to Australia[17] and this remains the only study relating to European immigrants. Subsequently, European studies reported similar observations relating to immigrants from distant geographical areas or 'exotic' countries.[14,18] A UK clinic study found four to six times the rate of autism in second-generation African–Caribbean children.[19] An Australian study[20] found an increased risk associated with having a mother born outside Australia, with the greatest risk in those born in North East and South East Asia. Maternal place of birth outside Europe or North America has also been reported to be associated with a relative risk of autism of 1.4–3.0 for children born in Denmark and Sweden respectively,[9] and a three to four times greater prevalence in children of mothers born in Somalia emigrating to Sweden.[21]

Complex paternal sociobiological factors may act as confounders in relation to both parental age and immigration. Three processes operating in men with genetic vulnerability to autism have been suggested: seeking an immigrant partner who may be less aware of autism-related social problems than someone raised in his own cultural milieu; having greater difficulty finding a partner (with resultant older paternal age); or selective immigration of those at higher risk of autism-spectrum disorders.[22,23] One study examining the relationship between autism-related personality traits and delayed paternity has not found an association.[24] There is some support for a trend to

seeking an immigrant partner but not for selective immigration, in the finding that maternal country of origin has a greater effect than paternal country of origin.[11] These key studies are specific to the Nordic countries, and replication in other geographical regions may be necessary before the results can be generalised.[9]

In contrast to these reports, suggested relationships linking autism-spectrum disorders with demographic and ethnicity factors have been dismissed as being based on small numbers and 'not convincing'.[25] Some large population prevalence studies from the USA have also not supported a relationship between either ethnicity or immigrant status and rates of autism, and in particular the rate of autism-spectrum disorders in Black children was found to be comparable with other ethnic groups,[26] and neither maternal ethnicity nor immigration were an influence.[27,28]

The inconsistency between reports raises the question as to whether the effect of ethnicity and/or parental immigration on the risk of autism-spectrum disorders differs between countries or regions, such as between the USA and Europe, as has also been suggested in the case of schizophrenia.[15]

There are a limited number of studies looking at the relationship between parental immigration and other types of developmental disability. However, where this has been explored, it appears that children of immigrant parents are at risk from a greater severity of neurodisability in general, whether physical, intellectual, social or sensory functioning,[19,29,30] and this has also been suggested for autism-spectrum disorders.[21] High levels of recessive genetic conditions have been observed in some specific populations,[29] and there has been repeated suggestion of a possible role for intrauterine infection in relation to autism and disability in general,[9,19] but these and other aetiological factors have not been investigated systematically.

Despite the emerging research findings, immigration as a possible aetiological factor in the increasing prevalence of autism-spectrum disorders has been underinvestigated. This study aims to examine the hypotheses that maternal ethnicity and/or immigration are linked to childhood autism-spectrum disorders in the second generation, in the context of conflicting evidence relating to ethnicity and parental immigration as risk factors for autism.

Method

The study population was drawn from children presenting to the paediatric child development services of two adjacent south London boroughs, Wandsworth and Lambeth. These boroughs were selected because of differences in the demographic and economic profile, the former being relatively affluent with a Black and minority ethnic population of 22%, and the latter with higher levels of social adversity and a Black and minority ethnic population of 38%.[31]

Retrospective analysis of case notes was undertaken. Participants were all children diagnosed with autism-spectrum disorders during a 6-year period (1 September 1999 to 31 August 2005). The inclusion criteria were that children were born in the UK and resident in the borough at the time of diagnosis.

The child development teams were organised differently, but were both established multidisciplinary services providing autism-specific assessments through child observation, individual assessment and clinical interview (using tools such as the Autism Diagnostic Interview (ADI–R),[32] Diagnostic Interview for Social and Communication Disorders (DISCO)[33] and Autism Diagnostic Observation Schedule (ADOS)).[34] In most cases a diagnosis was made following a multidisciplinary team assessment, and in both services by reference to ICD–10 criteria.[35] A very small number of older children were diagnosed by other services in the boroughs during the same period (e.g. psychology or mental health services) prior to being known to the paediatric service. In two cases the exact date of diagnosis was unclear and the age at diagnosis was given in whole years. The diagnosis was recorded as autism or a pragmatic category of other autism-spectrum disorders for those with atypical autism, high-functioning autism or Asperger syndrome, as these descriptive terms were used inconsistently.

Details of parental ethnic group and country of birth were routinely recorded at assessment in both centres. Parental country of birth was assigned to region according to the 2001 Census classification of countries by continent for Europe, Africa and Asia. We created a separate subgroup born in the Caribbean because of the substantial numbers from that region. Other countries in the Americas and Oceania have been grouped as 'elsewhere' because of extremely small numbers. Because of the lower rates of recording for fathers, a pragmatic decision was made to use the mother's ethnic group and region of birth as the primary markers.

The rates of autism-spectrum disorders by maternal region of birth and ethnic group were calculated with reference to the 2001 Census population data, made available from the London Health Observatory and the Office for National Statistics. Rates were calculated by dividing the number of mothers in each ethnic or regional subgroup by the 2001 female population aged 16–39 years in that borough, representing women of approximate childbearing age. Mothers of mixed Black/White or Asian/White ethnicity were added to the Black and Asian ethnic groups respectively, due to small numbers, and the same groups were combined in the population data.

Correction was made for possible variation in rate of autism-spectrum disorders resulting from differences in family size in different ethnic subgroups. Average family size, estimated from the total period fertility rate (TPFR), was obtained for ethnic groups from a report by the Data Management and Analysis Group of the Greater London Authority, 2002.[36] The TPFRs for detailed ethnic subgroups were weighted according to the distribution of these subgroups in each borough's population, to give an overall TPFR for each of the Black and Asian populations in the two boroughs. Information on TPFR was available only by ethnic group and not for country of birth.

Relative risks for having a child with an autism-spectrum disorder were calculated relative to White ethnic group and UK country of birth. The 95% confidence intervals for relative risks were obtained using the Confidence Intervals Analysis computing package, version 1.2 in Windows XP.[37] Relative risks were considered statistically significant if the confidence interval did not include one. In the text, the effect size is generally quoted as the lower end of the confidence interval, giving a conservative estimate of the increased risk.

This study was approved by the Research and Development Committee of South West London and St George's Mental Health NHS Trust and permission to access clinical data was given by the Lambeth Primary Care Trust Caldicott Guardian.

Results

Data were collected on all 428 children diagnosed with autism or autism-spectrum disorders over the 6-year period, of which 267 were in Wandsworth and 161 in Lambeth.

Demographic characteristics

About four-fifths of children with a diagnosis of autism-spectrum disorder were male in both boroughs (Table 1). The average age

Table 1 Age at diagnosis of autism–spectrum disorder, by gender and maternal ethnicity, within borough of residence[a]

	Lambeth ($n = 161$)				Wandsworth ($n = 267$)			
		Age at diagnosis, years				Age at diagnosis, years		
	n (%)	Mean (s.d.)	Range	*P*	*n* (%)	Mean (s.d.)	Range	*P*
Overall		6.2 (2.4)	2.2–15.6			4.6 (2.4)	1.4–18.0	
Gender				0.49				0.96
Male	124 (77.5)	6.3 (2.5)	2.2–15.6		225 (84.6)	4.6 (2.3)	1.4–18.0	
Female	36 (22.5)	6.0 (1.8)	3.5–12.2		41 (15.4)	4.6 (2.9)	2.0–16.0	
Mother's ethnicity				0.68				0.002
White	27 (16.8)	6.1 (2.4)	3.0–13.0		163 (61.0)	4.9 (2.5)	1.4–16.0	
Black[b]	97 (60.2)	6.3 (2.4)	2.8–15.6		78 (29.2)	3.7 (1.4)	1.8–10.0	
Asian[c]	13 (8.1)	6.1 (2.4)	4.0–12.5		16 (6.0)	5.3 (4.2)	2.1–18.0	
Other/not known[d]	24 (14.9)	6.0 (2.7)	2.2–12.4		10 (3.7)	4.9 (2.1)	2.5–8.5	

a. Gender was missing for one child in each of Lambeth and Wandsworth; age was missing for three males in Lambeth and one male in Wandsworth.
b. Includes mixed Black/White (four in Lambeth and seven in Wandsworth).
c. Includes one mixed Asian/White in Lambeth.
d. 'Other' comprises one mixed Black/Asian in Lambeth, and two Chinese in Wandsworth.

for diagnosis was higher in Lambeth than in Wandsworth (6.2 *v.* 4.6 years respectively). Mean age at diagnosis did not differ significantly between males and females in either borough, but showed a significant variation across ethnic groups in Wandsworth, with the Black ethnic group having the youngest age at diagnosis.

For those children in whom a diagnostic subtype was identified, around two-thirds were classified as having autism and a third as having autism-spectrum disorder (Table 2). There was little difference in these proportions between males and females, but in Wandsworth the proportion with autism was significantly higher for the children of Black and Asian ethnic groups compared with the White group.

Incidence of autism-spectrum disorders by region of birth of mother

The estimated annual incidence of having a child with an autism-spectrum disorder was calculated according to the region of birth of the mother (Table 3). Compared with mothers born in the UK, there was a significantly increased risk of having a child with an autism-spectrum disorder for immigrant mothers born in Africa, the Caribbean and Asia; this result was seen consistently in both Wandsworth and Lambeth. The highest relative risk was observed for those born in the Caribbean, where the risk was estimated to be at least five times that of UK-born mothers, in both boroughs. There was no significant increase in risk for those born in other European countries.

Incidence of autism-spectrum disorders by ethnic group of mother

The estimated annual incidence of having a child with an autism-spectrum disorder was calculated for different maternal ethnic groups (Table 4). Compared with White mothers, there was a significantly higher risk for mothers of Black ethnic origin, with at least a fivefold increase in risk observed in Lambeth and a threefold increase in Wandsworth. The relative risk for mothers of Asian ethnic origin compared with White mothers was only statistically significant in Lambeth, where at least a threefold increased risk was indicated.

Incidence of autism-spectrum disorders by region of birth and ethnic group of mother

In order to differentiate the effect of ethnicity from the effect of region of birth, each ethnic group was further divided into mothers who were born in the UK and those not born in the UK. The relative risk of having a child with an autism-spectrum disorder was calculated for each subgroup compared with a baseline of White women born in the UK (Table 5). There was a significantly increased risk of having a child with an autism-spectrum disorder for mothers of Black ethnic origin born outside the UK, of at least ninefold in Lambeth and fivefold in Wandsworth. Similarly, the risk was significantly increased for mothers of Asian ethnic origin born outside the UK by a factor of 5 in Lambeth and 1.4 in Wandsworth. Conversely, most of the subgroups of mothers born in the UK failed to show a significant increase in the risk of autism-spectrum disorders regardless of ethnic group, the exception being mothers of Black ethnic origin born in the UK in Lambeth. There was also no significant difference in risk for White immigrants to the UK.

Since the probability of having a child with an autism-spectrum disorder is likely to increase with family size, we adjusted these relative risks for the larger average family size among Black and Asian ethnic groups. The same adjustment was applied to both UK and non-UK subgroups, as a differential adjustment factor was not available by region of birth. The relative risk for mothers of Black ethnic origin born outside the UK remained statistically significant in both boroughs, with an increased risk of approximately three- to fivefold relative to White UK-born mothers. A significant effect was also still observed in Lambeth for mothers of Asian ethnic origin born outside the UK, and for mothers of Black ethnic origin born within the UK.

Discussion

This study found a significant association between maternal immigration and the risk of having a child with an autism-spectrum disorder. The immigration effect varies by maternal region of origin, with the highest risk observed for immigrants from the Caribbean, followed by those from Africa and then Asia. There is no apparent effect for immigrants from Europe.

There was little evidence of an independent ethnic effect on the risk of autism-spectrum disorders in the absence of maternal immigration, since the association with ethnicity did not remain significant when considered simultaneously with region of birth, except for UK-born Black individuals in Lambeth where the result just reached significance. Therefore it appears that it is immigration, not ethnicity, which is the main candidate for a risk factor.

Table 2 Diagnostic subgroups by gender and maternal ethnicity, within borough of residence

	Lambeth ($n = 161$)		Wandsworth ($n = 267$)	
	n (%)	*P*	*n* (%)	*P*
Overall				
Autism	104 (70.3)		159 (62.6)	
Other autism-spectrum disorders	44 (29.7)		95 (37.4)	
Unconfirmed subtype	13		13	
Gender[a]		0.98		0.34
Male				
Autism	80 (70.8)		131 (61.2)	
Other autism-spectrum disorders	33 (29.2)		83 (38.8)	
Unconfirmed subtype	11		11	
Female				
Autism	24 (70.6)		27 (69.2)	
Other autism-spectrum disorders	10 (29.4)		12 (30.8)	
Unconfirmed subtype	2		2	
Mother's ethnicity[b]		0.77		0.047
White				
Autism	17 (65.4)		86 (56.2)	
Other autism-spectrum disorders	9 (34.6)		67 (43.8)	
Unconfirmed subtype	1		10	
Black				
Autism	66 (72.5)		55 (71.4)	
Other autism-spectrum disorders	25 (27.5)		22 (28.6)	
Unconfirmed subtype	6		1	
Asian				
Autism	8 (72.7)		12 (75.0)	
Other autism-spectrum disorders	3 (27.3)		4 (25.0)	
Unconfirmed subtype	2		0	

a. Gender was not recorded for two children: one with other autism-spectrum disorder in Lambeth, and one with autism in Wandsworth.
b. Results are not presented for ethnicity 'other/not known'.

Table 3 Incidence and relative risk of autism-spectrum disorders, 1999–2005, by region of birth of mother (immigration effect)

Region of birth of mother[a]	Mothers of children with autism-spectrum disorders, *n*	Female borough population aged 16–39, *n*	Annual incidence of having a child with an autism-spectrum disorder (per 1000)	Relative risk *v.* UK[b]	95% CI for relative risk[b]
Lambeth ($n = 137$)					
UK	48	44 015	0.18	1.00	–
Other Europe	8	5581	0.24	1.31	0.62–2.78
Africa	56	6482	1.44	**7.92**	**5.39–11.6**
Caribbean	14	1283	1.82	**10.01**	**5.53–18.1**
Asia	10	2310	0.72	**3.97**	**2.01–7.84**
Elsewhere	1				
Wandsworth ($n = 258$)					
UK	152	48 858	0.52	1.00	–
Other Europe	20	5276	0.63	1.22	0.76–1.94
Africa	47	4621	1.70	**3.27**	**2.36–4.53**
Caribbean	13	470	4.61	**8.89**	**5.08–15.5**
Asia	22	3402	1.08	**2.08**	**1.33–3.25**
Elsewhere	4				

a. Region of birth was missing for 24 mothers in Lambeth and 9 mothers in Wandsworth.
b. Statistically significant results are shown in bold.

Table 4 Incidence and relative risk of autism-spectrum disorders, 1999–2005, by ethnicity of mother

Ethnicity of mother	Mothers of children with autism-spectrum disorders, *n*	Female borough population aged 16–39, *n*	Annual incidence of having a child with an autism-spectrum disorder (per 1000)	Relative risk *v.* White[a]	95% CI for relative risk[a]
Lambeth ($n = 137$)					
White	27	41 332	0.11	1.00	–
Black[b]	97	17 932	0.90	**8.28**	**5.41–12.7**
Asian[c]	13	3219	0.67	**6.18**	**3.19–12.0**
Wandsworth ($n = 259$)					
White	163	55 404	0.49	1.00	–
Black[b]	78	6908	1.88	**3.84**	**2.93–5.02**
Asian[c]	16	4416	0.60	1.23	0.74–2.06

a. Statistically significant results are shown in bold.
b. Including mixed Black/White.
c. Including mixed Asian/White.

Table 5 Incidence and relative risk of autism-spectrum disorders, 1999–2005, by ethnicity and immigration status of mother

Ethnicity of mother and whether born in the UK or not	Mothers of children with autism-spectrum disorders, *n*	Female borough population aged 16–39, *n*	Annual incidence of having a child with an autism-spectrum disorder (per 1000)	Relative risk *v.* White UK-born[a]	95% CI for relative risk[a]	Estimated average family size, *n*	Relative risk *v.* White UK-born, adjusted for family size[a]	95% CI for adjusted relative risk[a]
Lambeth (*n* = 137)								
White						1.24		
UK-born	19	30 973	0.10	1.00	–		1.00	–
Immigrant	8	10 359	0.13	1.26	0.55–2.87		1.26	0.55–2.87
Missing	0							
Black[b]						2.31		
UK-born	25	10 581	0.39	**3.85**	**2.12–6.99**		**2.07**	**1.14–3.75**
Immigrant	69	7351	1.56	**15.30**	**9.21–25.40**		**8.21**	**4.94–13.63**
Missing	3							
Asian[c]						2.38		
UK-born	2	1680	0.20	1.94	0.45–8.32		1.01	0.23–4.33
Immigrant	10	1539	1.08	**10.59**	**4.93–22.70**		**5.52**	**2.57–11.83**
Missing	1							
Wandsworth (*n* = 259)								
White						1.24		
UK-born	132	41 888	0.53	1.00	–		1.00	–
Immigrant	31	13 516	0.38	0.73	0.49–1.08		0.73	0.49–1.08
Missing	0							
Black[b]						2.30		
UK-born	19	4384	0.72	1.38	0.85–2.22		0.74	0.46–1.20
Immigrant	57	2524	3.76	**7.17**	**5.27–9.75**		**3.86**	**2.84–5.26**
Missing	2							
Asian[c]						2.30		
UK-born	0	1994	–	–	–		–	–
Immigrant	16	2422	1.10	**2.10**	**1.25–3.52**		1.13	0.67–1.90
Missing	0							

a. Statistically significant results are shown in bold.
b. Including mixed Black/White.
c. Including mixed Asian/White.

The relationship between maternal immigration and risk of autism-spectrum disorders did however vary by ethnicity, with a stronger association observed for Black immigrants than for Asian immigrants, and no apparent effect for White immigrants. Whereas the increased risk appears unequivocal for Black immigrant mothers, the message is less clear for Asian immigrant mothers, where a significant effect was only seen in one borough, Lambeth. This might be explained by differences in composition of the Asian groups in each borough: in Lambeth, all Asian immigrant mothers originated in the Indian subcontinent, whereas in Wandsworth this proportion was only 56% (9/16), the remainder originating in the Far East, Middle East or Africa.

The variation in risk of autism-spectrum disorders by ethnicity among immigrant mothers may simply be a confounding effect with country of origin. For example, the high rates of autism-spectrum disorders observed for the children of Black immigrant mothers reflect the high rates found for mothers immigrating from the Caribbean and Africa. Alternatively, there may be a more complex explanation, with a combined effect of ethnicity and region of origin among immigrants from these countries.

These findings appear to be different from those reported by US studies. This may partly be related to differing population characteristics. In contrast to the Black immigration patterns in the USA, the substantial proportion of Black immigration into Europe has occurred mainly over the past 50 or so years. UK-born Black mothers are therefore likely to be second- or third-generation immigrants. The increased risk of autism-spectrum disorders in Black mothers born in the UK was lower than that observed for their Black immigrant counterparts. This raises the question of whether we might be observing evidence of a progressive attenuation of the effect of immigration generation on generation. This effect might account for the differences in the findings relating to settled ethnic populations between European studies and those from the USA, but would not explain differences relating to recent immigration.

It is unclear as to how immigration may exert an increased risk and clues from research into immigration and other aetiological factors in related neuropsychiatric or neurodevelopmental disorders are sparse. Autism-spectrum disorders are one element of an interwoven tapestry of overlapping and co-occurring neurodevelopmental disorders such as attention-deficit hyperactivity disorder, developmental coordination disorder and Tourette syndrome. There does not appear to be literature suggesting a link between parental immigration and the risk of any of these disorders.

However, there are interesting parallels with the literature on schizophrenia and psychosis. An increased rate of psychosis is reported to be present in all immigrants irrespective of ethnicity, suggesting an explanation that is environmental rather than genetic. However, similar to the findings of this study, there is a particularly high risk seen in the second-generation African–Caribbean population.[38] This raises the question as to what aetiological factors might be common to both psychosis and autism-spectrum disorders that are not shared by those co-occurring neurodevelopmental disorders. Increased paternal age and urban upbringing are also factors associated with increased risk in both psychosis and autism-spectrum disorders. Other diverse hypotheses put forward to explain increased risk in psychosis include selective immigration of parents with higher risk, obstetric complications resulting from cephalopelvic disproportion due to better nutrition, exposure to novel neurotropic virus infection

and prenatal exposure to vitamin D deficiency caused by dark skinned immigrants' reduced exposure to sun in Northern countries.[15] Most of these factors have also been suggested as proposed aetiological triggers for risk of autism-spectrum disorders although few have been systematically examined[39] and therefore remain speculative. For schizophrenia, none have withstood systematic examination.[15] There is no clear emerging picture as to possible aetiological factors in either schizophrenia or autism-spectrum disorders.

It is important to recognise that the term 'ethnicity' as used in population and health research is a multifaceted and largely socially determined concept. Ethnicity may not map directly to ethnic and biological make-up or genetic, allelic or epigenetic differences likely to be important in understanding the cause of increased risk. This is clearly an area that requires more research.[38]

Strengths and limitations

In common with other epidemiological studies on the impact of environmental factors on child development, we acknowledge the potential impact of multiple confounding factors that must necessitate caution before reaching firm conclusions about any causal effect of immigration.[40,41] As a result of the retrospective collection of clinic data, and the use of a population comparison group, we were unable to adjust for a number of known risk factors for autism-spectrum disorders that could potentially have differed between the groups of interest in this study. These risk factors include maternal and paternal ages, maternal education, birth weight and gestational age. One factor that we were able to incorporate was differing family size between ethnic groups, but these data were not available by region of birth. The size of the increased risks observed for Black and Asian immigrants are sufficiently large that it seems unlikely they could be completely eliminated through adjustment for confounding factors. In the text we have presented these increased risks conservatively by quoting the lower end of the confidence interval; if the truth is closer to the point estimates presented in the tables, then the risks are even higher. However, further research is needed to quantify the effect of potential confounding variables on the associations found here.

The study presents 6 years of data from two boroughs where service provision and population catchments were largely coterminous. We chose to analyse the boroughs separately because we anticipated there may have been important differences in clinic populations and service provision. Clinic population differences were in fact evident. It is likely that the difference in mean age at diagnosis, and in the number of cases diagnosed, is a reflection of a substantially longer waiting time in one borough. In particular, there was a marked difference between boroughs in the mean age at diagnosis for children of Black maternal ethnic origin, with very few diagnosed over 5 years of age in Wandsworth compared with Lambeth (10/78 (13%) *v.* 69/95 (73%) respectively). Our clinical impression was that in Wandsworth there was an excess of boys of Black ethnic origin with very severe impairment who were likely to present, and therefore be diagnosed, early but this study was unable to examine this further. Differences in the proportions assigned to each diagnostic group and the gender ratios lie within ranges described elsewhere.[1] Although similar diagnostic criteria were applied, it is recognised that clinical practice and interpretation of criteria varies between different assessment teams.[1] We therefore feel that the significance of our key findings is strengthened by the fact that, despite these differences, the overall results from each borough were similar.

It is likely that there was a degree of underreporting of cases, and therefore it was not possible to derive true population incidence rates. First, these were clinical samples and population screening was not used. Second, the study did not include children on the waiting list. Third, our estimated incidence rates excluded mothers for whom data on ethnicity and region of birth were missing: 23 and 24 mothers respectively in Lambeth and 8 and 9 mothers respectively in Wandsworth. If each ethnic group and region of birth is equally underrepresented, the relative risks will however be unaffected. Finally, it is likely that other services, such as clinical psychology or child and adolescent mental health teams, would have had some diagnostic role in children with autism-spectrum disorders presenting with certain behavioural or mental health problems who might therefore be excluded from this study. We believe, however, that in both boroughs, the paediatric services were not only responsible for diagnosing the vast majority of autism-spectrum disorder cases, but were likely to have involvement with most other cases through their statutory role in assessment of special educational needs; according to the Office of National Statistics, 97% of children with autism-spectrum disorders have a statement of special educational need.[1]

Other possible causes of bias include: inequality of access to services according to ethnicity; cultural factors affecting rates of referral and diagnosis; and possible influence of ethnicity on professional decision-making, although the latter has previously been discounted as a significant factor in developmental disorders.[42] Later referral and diagnosis have been reported for Black children in the USA.[26,43] Our study showed inconsistent effects with Black children diagnosed earlier in one borough compared with Asian and White children, and the trend reversed in the other borough. Children with autism-spectrum disorders who have less educated parents are less likely to be diagnosed by local health services,[1,26] which might imply that we have underestimated, rather than overestimated, the effect of ethnic and immigration factors particularly in the borough with higher levels of social adversity.

This study was unable to examine any factors relating to possible parental vulnerability to autism-related conditions. We used maternal ethnicity and immigration as the primary markers, but were unable to examine the relationship of increased risk of autism-spectrum disorders to paternal factors. Where data were available for both parents, we found the vast majority shared the same ethnic group (and country of birth): 86% (90%) respectively for Wandsworth and 73% (84%) for Lambeth. Because the majority of parents shared ethnicity and place of birth, it is possible that maternal risk is actually a proxy for paternal risk, although one study correcting for this effect has found the latter was not a risk factor.[11]

This study was unable to distinguish between those immigrant parents who arrived recently and those arriving as children. This would merit further study to explore the nature of possible risk factors.

There are some limitations in the use of the 2001 Census population data. Recent population movements from areas of social and political upheaval have meant that the population of parts of London can be subject to considerable change over a short period of time. However, we were fortunate that the Census date was close to the midpoint of our study. We would also acknowledge certain limitations of comparing clinic-based records of ethnic group (derived from both self-report and professionals' clinical notes) with that of the ethnic group categories of the census (derived from self-reported information). We have used a composite 'Black' category, including Black African, Black Caribbean, and a small number of mixed ethnicity parents, which may have masked differential effects for these subgroups. Lack of

masking to study aims could potentially have affected attribution of ethnicity but only in those cases where recording was unclear and this was rare.

Implications and future research

This study confirms that there is an excess risk of autism-spectrum disorders in children of mothers who have immigrated to the UK from certain geographical regions, with Caribbean-born mothers having a higher risk than those born in Africa or Asia, and no increased risk for mothers of European origin. Although there is some variation in risk of autism-spectrum disorders according to ethnicity among immigrant mothers, with the highest risk seen for Black mothers, there was little evidence of an effect of ethnicity among non-immigrants. Therefore, it appears that it is immigration, not ethnicity, which is the prime suspect. Caution must be exercised before concluding that the association with immigration is causal however, given the epidemiological nature of the study.[41] Our findings differ from those reported in the USA, but are consistent with reports from Europe and Australia.

Population immigration could be a contributing factor in the rising prevalence of autism-spectrum disorders in areas where there is a large immigrant population. These findings have significant implications for the immigrant parents who may have experienced great adversity prior to their arrival, as well as for services in meeting their complex needs. This phenomenon deserves more investigation than it has received to date.

Four specific questions suggested for further study are: whether the relationships found here survive adjustment for additional confounding factors; whether the effect attributed to maternal immigration could be a proxy for paternal immigration; whether immigration during a mother's childbearing years has a similar risk to immigration in her early childhood; and whether continuing immigration effects are apparent in second and subsequent generations.

D. V. Keen, FRCPCH, Developmental Paediatrics, St George's Healthcare NHS Trust, London; **F. D. Reid**, MSc, Community Health Sciences, St George's, University of London; **D. Arnone**, DM, MRCPsych, Neuroscience and Psychiatry Unit, University of Manchester and University Department of Psychiatry, Warneford Hospital, Oxford, UK

Correspondence: Daphne Keen, Consultant Neurodevelopmental Paediatrician, Room 2.35, 2nd Floor Clare House, St George's Hospital, Blackshaw Road, London SW17 0QT, UK. Email: daphne.keen@stgeorges.nhs.uk

First received 26 Feb 2009, final revision 23 Oct 2009, accepted 5 Jan 2010

Funding

D.A. is currently supported by the Medical Research Council UK.

Acknowledgements

Thanks are due to the London Health Observatory for provision of population data and family size by ethnicity and to Dr Jayne Walters and colleagues at the Mary Sheridan Centre, Lambeth, for facilitating access to clinical records.

References

1 Baird G, Siminoff E, Pickles A, Chandler S, Loucas T, Meldrum D, et al. Prevalence of disorders of the autistic spectrum in a population cohort of children in South Thames: the Special Needs and Autism Project (SNAP). *Lancet* 2006; **368**: 210–5.

2 Fombonne E. The prevalence of autism. *JAMA* 2003; **289**: 87–9.

3 Keen DV, Ward S. Children and young people with autistic spectrum disorder – a population profile. *Autism* 2004; **8**: 39–48.

4 Gillberg C, Coleman M. The genetics of autism. In *The Biology of the Autistic Syndromes (3rd edn)*. Mac Keith Press, 2000.

5 Harrison MJ, O'Hare AE, Campbell H, Adamson A, McNeillage J. Prevalence of autistic spectrum disorders in Lothian, Scotland: an estimate using the 'capture-recapture' technique. *Arch Dis Child* 2006; **91**: 16–9.

6 Roberts EM, English PB, Grether JK, Windham GC, Somberg L, Wolff C. Maternal residence near agricultural pesticide applications and autism spectrum disorders among children in the California Central Valley. *Environ Health Perspect* 2007; **115**: 1482–9.

7 Hultman CM, Sparen P, Cnattingius S. Perinatal risk factors for infantile autism. *Epidemiology* 2002; **13**: 417–23.

8 Glasson EJ, Bower C, Petterson B, de Klerk N, Chaney G, Hallmayer JF. Perinatal factors and the development of autism: a population study. *Arch Gen Psychiatry* 2004; **61**: 618–27.

9 Kolevzon A, Gross R, Reichenberg A. Prenatal and perinatal risk factors in sutism. *Arch Pediatr Adolesc Med* 2007; **161**: 326–33.

10 Reichenberg A, Gross R, Weiser M, Bresnahan M, Silverman J, Harlap S, et al. Advancing paternal age and autism. *Arch Gen Psychiatry* 2006; **63**: 1026–32.

11 Lauritsen MB, Pedersen CB, Mortensen PB. Effects of familial risk factors and place of birth on the risk of autism: a nationwide register-based study. *J Child Psychol Psychiatry* 2005; **46**: 963–71.

12 Durkin MS, Maenner MJ, Newschaffer CJ, Lee LC, Cunniff CM, Daniels JL, et al. Advanced parental age and the risk of autism spectrum disorder. *Am J Epidemiol* 2008; **168**: 1268–76.

13 Tsuchiya KJ, Matsumoto K, Miyachi T, Tsujii M, Nakamura K, Takagai S, et al. Paternal age at birth and high-functioning autistic-spectrum disorder in offspring. *Br J Psychiatry* 2008; **193**: 316–21.

14 Gillberg C, Steffenberg S, Borjesson B, Anderson L. Infantile autism in children of immigrant parents. A population-based study from Göteborg, Sweden. *Br J Psychiatry* 1987; **150**: 856–8.

15 Cantor-Graae E, Selten JP. Schizophrenia and migration: a meta-analysis and review. *Am J Psychiatry* 2005; **162**: 12–24.

16 Gillberg C, Steffenberg S, Schaumann H. Is autism more common now than ten years ago? *Br J Psychiatry* 1991; **158**: 403–9.

17 Haper J, Williams S. Infantile autism: the incidence of national groups in a New South Wales survey. *Med J Aust* 1976; **10**: 299–301.

18 Wing L. Childhood autism and social class: a question of selection? *Br J Psychiatry* 1980; **137**: 410–7.

19 Goodman R, Richards H. Child and adolescent psychiatric presentations of second-generation Afro-Caribbeans in Britain. *Br J Psychiatry* 1995; **167**: 362–9.

20 Williams K, Helmer M, Duncan GW, Peat JK, Mellis CM. Perinatal and maternal risk factors for autism spectrum disorders in New South Wales, Australia. *Child Care Health Dev* 2008; **34**: 249–56.

21 Barnevik-Olsson M, Gillberg C, Fernell E. Prevalence of autism in children born to Somali parents living in Sweden: a brief report. *Dev Med Child Neurol* 2008; **50**: 598–601.

22 Gillberg C, Schaumann H, Gillberg CI. Autism in immigrants: children born in Sweden to mothers born in Uganda. *J Intellect Disab Res* 1995; **39**: 141–4.

23 Gillberg CI, Gillberg C. Autism in immigrants: a population-based study from Swedish rural and urban areas. *J Intellec Disab Res* 1996; **40**: 24–31.

24 Puleo CM, Reichenberg A, Smith, CJ, Kryzak LA, Silverman JM. Do autism-related personality traits explain higher paternal age in autism? *Mol Psychiatry* 2008; **13**: 243–4.

25 Volkmar FR, Lord C, Bailey A, Schultz RT, Klin A. Autism and pervasive developmental disorders. *J Child Psychol Psychiatry* 2004; **45**: 135–70.

26 Yeargin-Allsop A, Rice C, Karapurkar T, Doernberg N, Boyle C, Murphy C. Prevalence of autism in a US metropolitan area. *JAMA* 2003; **289**: 49–55.

27 Croen LA, Grether JK, Hoogstrate J, Selvin S. The changing prevalence of autism in California. *J Autism Dev Disord* 2002; **32**: 207–15.

28 Croen LA, Grether JK, Selvin S. Descriptive epidemiology of autism in a Californian population: who is at risk? *J Autism Dev Disord* 2002; **32**: 217–24.

29 Morton R, Sharma V, Nicholson J, Broderick M, Poyser J. Disability in children from different ethnic populations. *Child Care Health Dev* 2002; **28**: 87–93.

30 Akinsola HA, Fryers T. A comparison of patterns of disability in severely mentally handicapped children of different ethnic origins. *Psychol Med* 1986; **16**: 127–33.

31 Office for National Statistics. *Census 2001*. ONS, 2003 (http://www.statistics.gov.uk/census2001/census2001.asp).

32 Lord C, Rutter M, Le Couteur A. Autism Diagnostic Interview-Revised: a revised version of a diagnostic interview for caregivers of individuals with possible pervasive developmental disorders. *J Autism Dev Disord* 1994; **24**: 659–85.

33 Wing L, Leekam SR, Libby SJ, Gould J, Larcome M. The Diagnostic Interview for Social and Communication disorderes: background, inter-rater reliability and clinical use. *J Child Psychol Psychiatry* 2002; **43**: 307–25.

34 Lord C, Risi S, Lambrecht L, Cook EH, Leventhal BL, DiLavore PC, et al. The Autism Diagnostic Observation Schedule-generic: a standard measure of social and communication deficits associated wtih the spectrum of autism. *J Autism Dev Disord* 2000; **30**: 205–23.

35 World Health Organization. *The ICD–10 Classification of Mental and Behavioural Disorders: Clinical Descriptions and Diagnostic Guidelines*. WHO, 1992.

36 Klodawski E. *Fertility of Ethnic Groups in London, 2002/3. DMAG Briefing 2004/24*. Greater London Authority, 2004.

37 Gardner MJ, Gardner SB, Winter PD. *Confidence Intervals Analysis (CIA), Version 1.2*. BMJ Publishing Group, 1992.

38 Singh SP, Burns T. Race and mental health: there is more to race than racism. *BMJ* 2006; **333**: 648–51.

39 Gillberg C, Coleman M. The epidemiology of autism and its spectrum disorders. In *The Biology of the Autistic Syndromes (3rd edn)*. Mac Keith Press, 2000.

40 Rettew DC. In this issue/abstract thinking: prenatal environment and mental health outcomes. *J Am Acad Child Adolesc Psychiatry* 2008; **47**: 1101–2.

41 Thapar A, Rutter M. Do prenatal risk factors cause psychiatric disorder? Be wary of causal claims. *Br J Psychiatry* 2009; **195**: 100–1.

42 Cuccaro ML, Wright HH, Rownd CV, Abramson RK, Waller J, Fender D. Professional perceptions of children with developmental difficulties: the influence of race and socioeconomic status. *J Autism Dev Disord* 1996; **26**: 461–9.

43 Mandell DS, Listerud J, Levy S, Pinto-Martin JA. Race differences in age at diagnosis among medicaid-eligible children with autism. *J Am Acad Child Adolesc Psychiatry* 2002; **41**: 1447–53.

Poems by doctors

Origami

Arthur Clark

At first, a long time ago,
there were only the folds of your armpits
and your buttocks and groin and eyes,
then the folds of the palms
whereby Madame Ricardo purported to know your future.
Much later came two folds on the forehead.
The folds at the eyes extended,
the ones between the nose and lip grew deep.
More folding. Vertical folds crossed the horizontal,
summers folded onto autumns, and the year
was folded by year and put on year away.
Vast sorrows were folded onto minor triumphs,
tucked under the slip of memory and lost.
Then I began to see the process,
in long shadows, by altered evening light,
as a process, and how each folding
brings you closer to perfection of the finished piece.

Arthur Clark is a neuropathologist practising in Calgary, Alberta. This poem is from *The Naked Physician: Poems about the Lives of Patients and Doctors*, edited by R. Charach (Quarry Press). Reproduced by kind permission of the author.

Chosen by Femi Oyebode.

The British Journal of Psychiatry (2010) 196, 281. doi: 10.1192/bjp.196.4.281