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The association between socioeconomic status and autism diagnosis in the UK for children aged five to eight years of age: findings from the Born in Bradford cohort.

Abstract

There has been recent interest in the relationship between socioeconomic status and the diagnosis of autism in children. Studies in the US have found lower rates of autism diagnosis associated with lower socioeconomic status, while studies in other countries report no association, or the opposite. This paper aims to contribute to the understanding of this relationship in the UK. Using data from the Born in Bradford cohort, comprising of 13,857 children born between 2007 and 2011, it was found that children of mothers educated to A-level or above had twice the rate of autism diagnosis, 1.5% of children (95% CI: 1.1%, 1.9%) compared to children of mothers with lower levels of education status 0.7% (95% CI: 0.5%, 0.9%). No statistically significant relationship between income status or neighbourhood material deprivation was found after controlling for mothers education status. The results suggest a substantial level of underdiagnosis for children of lower education status mothers, though further research is required to determine the extent to which this is replicated across the UK. Tackling inequalities in autism diagnosis will require action, which could include increased education, awareness, further exploration of the usefulness of screening programmes, and the provision of more accessible support services.

Introduction

When first identified in the 1940's (Kanner 1943) childhood autism was more narrowly defined and considered a relatively rare condition. During the 1960's and 1970's prevalence was estimated at around 2 to 4 per 10,000 in Europe and the US (Boat et al 2015). Reported prevalence increased substantially over subsequent decades (Weintraub 2011) and currently for children aged between eight and ten the prevalence of autism may be around 150 per 10,000 (1.5%) in the United States (US) (CDC 2014, Boat et al 2015) and 100 per 10,000 (1%) in the United Kingdom (UK) (Green et al. 2005 , Baird et al. 2006, Taylor et al 2013, Brett et al 2016). The reasons for this increase have been discussed and debated, and a number of factors have been identified including a widening of diagnostic criteria (Rice et al 2012), increased awareness amongst parents and clinicians (Weintraub 2011) and increased service provision (Elssabagh 2012).

While general awareness may have increased, it is also the case that achieving a diagnosis of autism for a child is a process that can take some time and require a good deal of determination from parents-carers. A recent study in the UK found that there was, on average, over three years between first contact with a health professional and a diagnosis of autism, with just over half of parents reporting dissatisfaction with the process (Crane et al 2016). Pressure on resources may be contributing to the situation where services are effectively rationed. In the UK local health budgets have been under strain (Iacobucci 2016), and this has impacted directly upon the provision of childhood autism services (Crowe & Salt 2015). The focus of this paper is whether, given this context, there are differences in childhood

autism diagnosis rates based on the socioeconomic status of parent-carers; where socioeconomic status is understood as an individuals position within society, based on relative economic prosperity and educational achievement (Segen 2006, Last 2007). It has been suggested that lower socioeconomic status parents-carers may be less knowledgeable about navigating through available service options (Pickard & Ingersoll 2015). So in this context, with differing levels of awareness, restricted provision and different resources available to parents-carers to push and navigate through health care systems, there is the potential for socioeconomic inequalities in diagnosis; and so inequalities in access to intervention and differential outcomes for children.

There have been a number of recent studies investigating the relationship between parent-carer socioeconomic status or education status and children with a diagnosis of autism (for an overview see Hrdlicka et al 2016). In the US, where most of these studies originate, a consistent finding has been that autism rates are higher for children of higher socioeconomic status (Durkin et al 2010, Fountain et al 2011, Thomas et al 2012) and for children whose parents have higher levels of education (Dickerson et al 2016). However the limited number of studies in other countries report different results. In Denmark no relationship with socioeconomic status was observed (Larsson et al 2005). In Sweden the opposite relationship to the US was observed, with higher rates of autism diagnosis for children of lower socioeconomic status families (Rai et al 2012).

Two studies in the UK have addressed this issue. A large well-designed study in South Thames of over 50,000 children aged nine to ten years found lower rates of

autism diagnosis for children of lower socioeconomic status (Baird et al 2006). Children were screened to identify those with a current clinical diagnosis of autism and those at risk of having undiagnosed autism, with a stratified subsample of children then received clinical diagnostic assessments in order to determine prevalence rates. They found that autism prevalence was higher for children with a parent who completed secondary school education, but there was no association with income or neighbourhood material deprivation, after taking account of parental education status. A more recent study in Cambridgeshire reported no differences in autism diagnosis by socioeconomic status (Sun et al 2014). However, this was a smaller study, of around 12,000 children, employing a less rigorous study design. These conflicting results raise some questions. It may be that the results reported by Sun et al 2014 are due to geographical differences or simply a less rigorous design than that employed by Baird et al 2006. Or it may be that differences reported by Baird et al 2006 no longer exist a decade or so later. This study looks to address these questions by examining the association between autism diagnosis and socioeconomic status in a different geographical area, the City of Bradford, and, crucially, to establish whether the socioeconomic differences in childhood autism diagnosis in the UK, first reported in 2006, still exist today.

Bradford is the sixth largest city in the UK with a population of about half a million and urban areas that are among the most deprived in the UK. Sixty percent of the babies born in the city are born into the poorest 20% of the population of England and Wales based on the British government's Index of Multiple Deprivation (DCLG 2011). Previous studies have found lower rates of autism for migrants and ethnic minorities in the US (Zaroff and Uhm 2012), but higher rates in the UK (Keen et al

2010). Bradford is a multicultural city, with a large Pakistani heritage population, and so is well suited to examining ethnic differences. Over a third of the mothers of Born in Bradford children were born outside the UK and around fifty percent of the children in the Born in Bradford cohort are of Pakistani heritage.

In summary, it appears that the relationship between childhood autism diagnosis and parent-carer socioeconomic status may be context dependent; influenced by factors such as levels of socioeconomic inequality and the availability of services. There is sparse conflicting evidence about the situation in the UK, but if access to a diagnosis requires prolonged assertive engagement with rationed health care systems then the potential for underdiagnosis may exist. This paper aims to contribute to the understanding of the relationship between socioeconomic status and autism diagnosis rates; and to estimate the potential size of any underdiagnosis that may exist for the specific population under study.

Method

This study uses data from the Born in Bradford birth cohort, consisting of 12,450 women recruited at 28 weeks of pregnancy, who gave birth at the Bradford Royal Infirmary to 13,857 children between the period 2007 to 2011. The Born in Bradford cohort study was created in response to rising concerns about the high rates of childhood morbidity and mortality in the city. The Born in Bradford cohort consist of over half of all children born at Bradford Royal Infirmary between 2007 and 2011 and is broadly representative of this wider population (Wright et al 2013). For a full description of the methods and data collected in the Born in Bradford study see Wright et al 2013. Informed consent was acquired prior to data collection and ethical

approval for all aspects of the research was granted by Bradford Research Ethics Committee (Ref 07/H1302/112). Cohort members gave their consent to access GP records via SystmOne, which currently has a complete coverage of all GP practices in Bradford. Linkage was carried out using NHS number, surname, gender and date of birth.

The outcome measure for this study was the presence of a Read (CTV3) code for autism recorded in a child's primary care records. Read codes are the standard clinical terminology system used in General Practice in the UK. First developed in the early 1980's, Read codes capture a range of patient information, including the diagnosis of conditions such as autism (Bentley et al 1996). The Read code system has gone through several developments (Robinson et al 1997) and the current analysis is based on Clinical Terms Version 3 (NHS Digital 2017). A list of Read codes used to determine the presence of autism and the specific codes that were recorded in the GP data are provided in supplementary material 1.

In order to examine the association between autism diagnosis and socioeconomic status a number of covariates, collected using a questionnaire administered at around 28 weeks of the pregnancy, were considered in the analysis. The individual income aspect of socioeconomic status was measured using means-tested benefit status. In the UK, being in receipt of means-tested benefits is recognised as measure of income poverty, as these benefits are frequently the only source of income and are paid at rates that put individuals below standard poverty lines (Platt 2007). In addition, we recorded residential address and this enabled the Index of Multiple Deprivation (IMD) 2010 score to be used as a measure of neighbourhood material

deprivation. The IMD is based on around forty indicators, organised into seven domains that capture the multifaceted nature of neighbourhood material deprivation (DCLG 2011). Educational achievement is often regarded as a good indicator of socioeconomic status, as it is normally fixed early in life (Grundy and Holt 2001) and is closely associated with levels of lifetime earnings (Smith and Middleton, 2007). We captured the highest level of qualification achieved by mothers (using equivalent UK and non-UK qualifications). In the analysis we considered those educated to A-level and above, compared to those with lower levels of qualifications. In the UK, achieving A-level or above requires continuing in education post age 16 years and this has been identified as a key measure of educational inequalities (Tackey et al 2011).

In addition to the variables measuring socioeconomic status we also consider measures of child and mother conditions that have been found, in certain studies, to be associated with childhood autism. The Born in Bradford recruitment questionnaire collected data on mother's ethnicity and country of birth. Linked maternity record data captured child birth-weight, gestational age and mother age at delivery and these covariates were also included in the analysis as previous studies have reported higher rates of autism diagnosis amongst low birth-weight and pre-term birth children (Schieve et al 2014) and differences by mother's age (Sandin et al 2016).

For this analysis data for children who were matched to GP records with coverage of at least eighty percent of time since birth were used, this excludes 1,004 children. A further 425 children who had died or withdrew from the study were also excluded.

This sample comprised of 12,428 children (90% of cohort), and its composition is shown in table 1. Table 1 also provides information on two aspects of missing data. First, the comparison between the sample used in the analysis and the full Born in Bradford cohort indicates that those included in the analysis presented in this paper are very similar to the full cohort; so the exclusion of those who died, withdrew or were not matched to GP records did not change the characteristics of the sample. Secondly, table 1 indicates the extent of missing data for each measure. All the children included in the sample for analysis had age and gender recorded, but for some covariates there was more missing data. For example, around 18% of those children matched to GP data had information missing on mother education level, either because no baseline questionnaire was completed or this information was not known or recorded in the completed questionnaire.

The cohort reflects Bradford's multicultural mix; around forty five percent of mothers are of Pakistani heritage and around a third of all mothers were born outside the UK. There are high levels of poverty, with over four in ten mothers receiving means tested benefits, and two thirds living in neighbourhoods with the highest national quintile of material deprivation in England (IMD 2010). The children are aged between five and eight at the point of data extract.

Table 1: Sample and cohort characteristics

Child/ mother characteristics	All Cohort (n = 13,857)	Sample: Matched to GP records (n = 12,428)	p value for difference
Child gender			p = 0.417
Male	51.1%	51.6%	
Female	48.9%	48.4%	
missing	*0*	*0*	
Child age at data extract			p = 0.607
Five	17.3%	17.8%	
Six	26.8%	26.9%	
Seven	26.7%	26.1%	
Eight*	29.2%	29.3%	
missing	*9*	*0*	
Mother ethnicity			p = 0.011*
White British	37.9%	37.9%	
Pakistani or Pakistani heritage	45.6%	46.9%	
Other	16.5%	15.2%	
missing	*407*	*330*	
Mother country of birth			p = 0.358
Born UK	63.3%	63.9%	
Not Born UK	36.7%	36.1%	
missing	*2,386*	*2,124*	
Child birth-weight (g): mean (std. dev.)	3,205 (573)	3214 (559)	p = 0.203
missing	*333*	*231*	
Child gestation (days): mean (std. dev.)	276 (13)	276 (13)	p = 1.000
missing	*332*	*230*	
Mother age at delivery			p = 0.880
Under 25	32.3%	32.0%	
25 to 29	32.6%	32.6%	
30 plus	35.1%	35.3%	
missing	*332*	*230*	
Mother benefit status			p = 0.234
In receipt of means-tested benefits	41.0%	41.8%	
Not in receipt of means-tested benefits	59.0%	58.2%	
missing	*2,422*	*2,154*	
IMD 2010 National quintile (n=10,303)			p = 0.902
Most materially deprived national quintile	66.5%	66.4%	
Not most materially deprived quintile	33.5%	33.6%	
missing	*2,386*	*2,125*	
Mother education			p = 0.569
Below A-level	59.6%	60.1%	
A-level or above	40.4%	39.9%	
missing	*2,541*	*2,257*	

* Statistically significant at 0.05 level

Logistic regression models were employed using Stata 13 (StataCorp. 2013) to estimate the predicted probability of having a diagnosis of autism recorded for different groups, based on economic disadvantage, neighbourhood material deprivation and mother's education status. These variables, and other covariates, were considered separately in univariate logistic regression models and then together in a single multivariate model. From this approach a final parsimonious model is developed to determine the association between socioeconomic variables and the probability of having an autism diagnosis in the primary care records. In the course of the analysis special attention is given to interpreting the results as effect sizes, including the impact of any findings on the specific population under study.

Results

We present the results for the cohort, looking at the overall rates of autism diagnosis and rates by gender, age, ethnicity and other child and mother characteristics. Then, after establishing these underlying rates of diagnosis, we consider variation associated with maternal socioeconomic and education status. 128 children were identified as having an autism diagnosis in their primary care records representing just over 1% of the sample, as shown in table 2. Although the number of cases reduces to 102 when considering just those children without missing data on any variable; this represents the same percentage of the population, just over 1%.

Table 2: Unadjusted prevalence rates of autism diagnosis from GP Read code data

Groups	Number of children	Children with autism diagnosis	Unadjusted Prevalence rate (Percentage, with 95% confidence intervals)
Matched to GP records	12428	128	1.03 (0.85 - 1.21)
No missing data on any variables	9941	102	1.03 (0.83 - 1.22)
Gender (12,438)			
Male	6418	103	1.60 (1.30 - 1.91)
Female	6010	25	0.42 (0.25 - 0.58)
Age of child at data extract (12,438)			
Five	2209	24	1.09 (0.65 - 1.52)
Six	3341	35	1.05 (0.70 - 1.39)
Seven	3240	34	1.05 (0.70 - 1.40)
Eight*	3638	35	0.96 (0.64 - 1.28)

* includes 158 children who have just reached the age of nine years (up to nine years and two days)

Autism diagnosis in relation to child gender and age

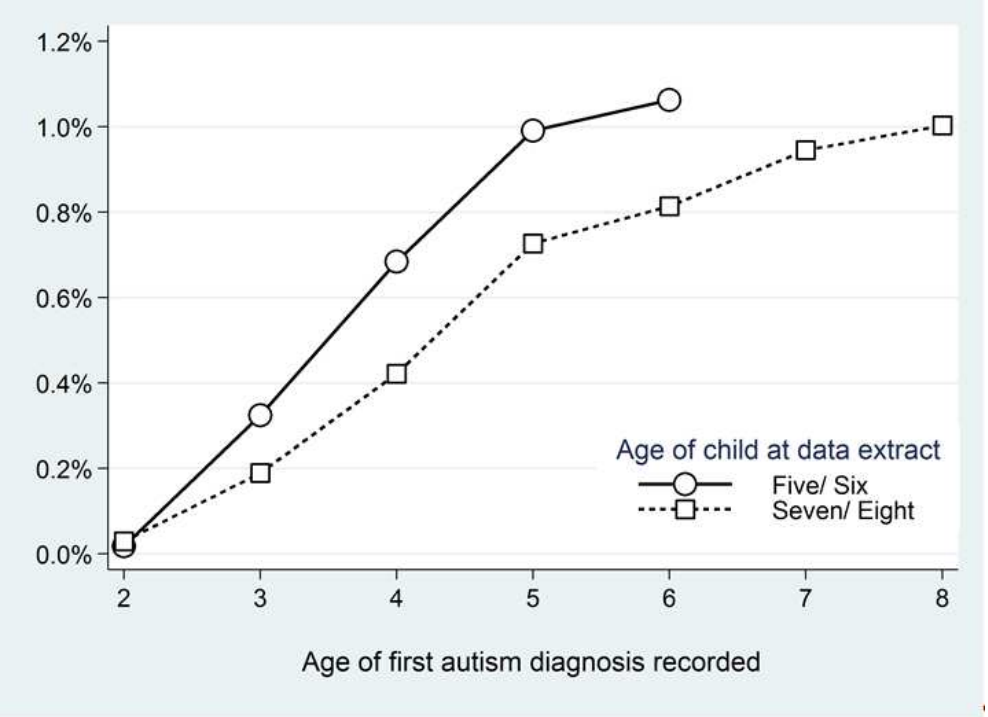
Table 2 indicates that boys had a far higher rate of recorded autism diagnosis than girls, around 1.6%, of boys compared to 0.4% of girls. Table 2 also shows the observed prevalence by age group. Children were aged between five and eight at the point of the primary care data extract and the prevalence of autism diagnosis is similar for children regardless of age. Over ninety percent of Read codes identified were for “Autism spectrum disorder” or “Childhood autism”, only a very small number of Read codes for “Atypical autism” and “Active infantile autism” were recorded, and there was one recording of Read code for “Asperger syndrome”, reflecting a move towards the DSM-5 categorisation (American Psychiatric Association 2013). (See supplementary material 1 for details of Read codes identified in the GP data.) Figure

1 illustrates that the cumulative prevalence is similar for older and younger children at the point of data extract but the trajectories of diagnosis by age differ, with children born more recently having higher prevalence at each age. This suggests increasing prevalence over time, although the numbers of diagnoses made at each year for each age group are small (see supplementary material 2).

Autism diagnosis in relation to child and maternal characteristics

Table 3 shows the results of the logistic regression analysis where each covariate is considered separately in univariate models and then all covariates are included in a single multivariate model. Effect sizes for covariates are expressed as odds ratios

Figure 1: Cumulative prevalence rates of autism diagnosis by age of diagnosis and age of child at data extract (July 2016)



Autism diagnosis in relation to child and maternal characteristics

Table 3 shows the results of the logistic regression analysis where each covariate is considered separately in univariate models and then all covariates are included in a single multivariate model. Effect sizes for covariates are expressed as odds ratios with 95% confidence intervals. The models presented in table 3 confirm the unadjusted observed prevalence reported in table 2. The largest variation in autism diagnosis is by child gender with boys being almost four times as likely to have a diagnosis of autism compared to girls. The size of this effect remains similar when considered in isolation and when controlling for all other covariates, and this suggests that the effect of gender is independent of any other association observed. Results confirm that the age of the child at the point of GP data extract is not associated with variation in autism diagnosis. There were no differences observed in the rates of autism diagnosis by child birth weight or gestational age at birth. There is some variation in autism diagnosis by age of the mother at birth. When considered in a univariate model rates were higher for children of older mothers; but, when considered along with all other covariates in a multivariate model, children of younger mothers were more likely to have a diagnosis of autism. These small, non-systematic, non-statistically significant differences suggest no underlying association. Some differences in autism diagnosis rates by ethnicity were observed. In the multivariate models children of ethnic minority mothers were less likely to have a diagnosis of autism. Children of Pakistani heritage mothers were around 70% less likely to have a recorded diagnosis compared to children of White British mothers, odds ratio 0.70 (95 CI: 0.41, 1.21). Differences by the mother's country of birth are less pronounced and also not statistically significant.

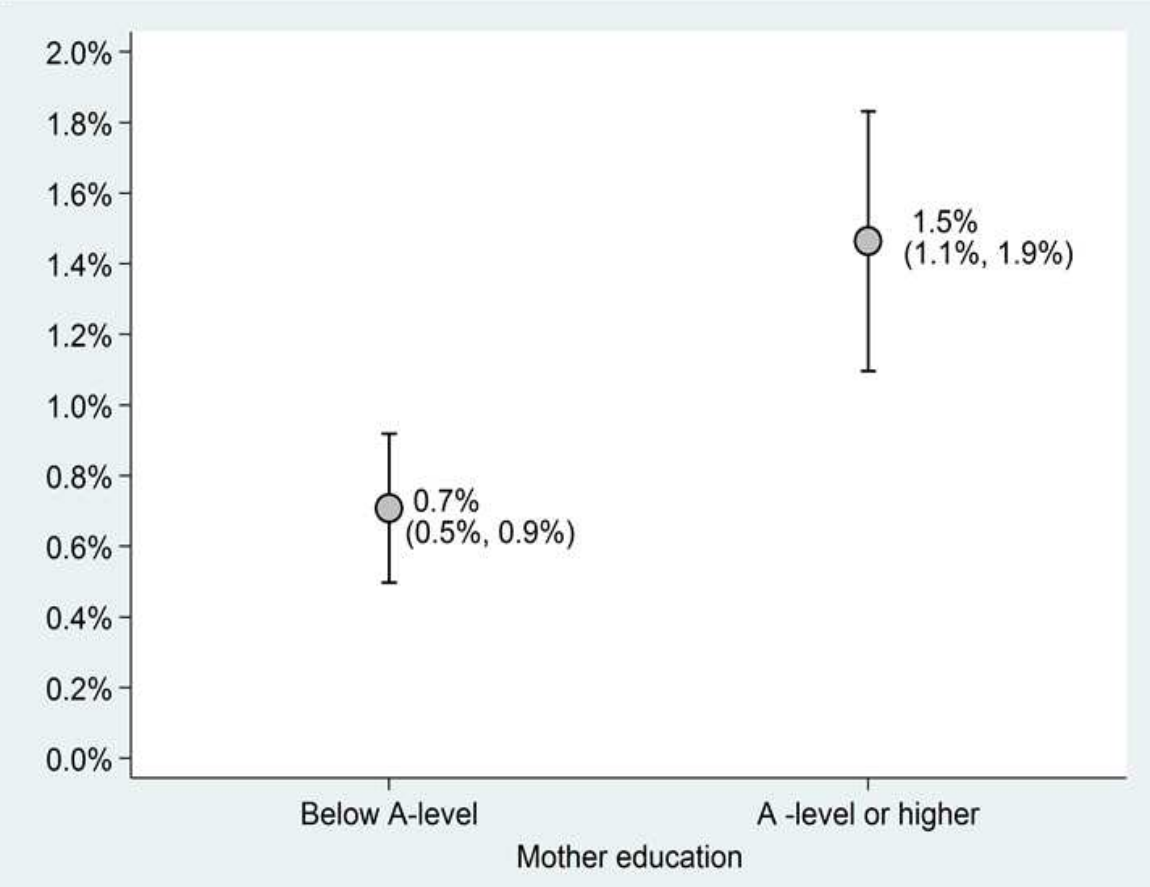
Table 3 univariate and multivariate logistic regression models predicting the odds ratio of having an autism diagnosis recorded in primary care records

	Univariate				Multivariate			
Covariate	Odds Ratio	95% CI: Low	95% CI: High	p-value	Odds Ratio	95% CI: Low	95% CI: High	p-value
Gender (reference: female)								
Male	3.90	2.52	6.05	<0.001	3.88	2.36	6.36	<0.001
Age at data extract (reference: Five)								
Six	0.96	0.57	1.62	0.890	1.07	0.60	1.93	0.813
Seven	0.97	0.57	1.63	0.896	1.13	0.63	2.05	0.680
Eight*	0.88	0.52	1.49	0.645	1.04	0.57	1.87	0.912
Child birth-weight (100g)	1.02	0.99	1.05	0.265	1.00	0.95	1.05	0.943
Gestation (weeks)	0.97	0.89	1.06	0.517	0.99	0.87	1.14	0.925
Mother age (reference: under 25)								
25 to 29	1.01	0.64	1.58	0.976	0.81	0.48	1.36	0.427
30 plus	1.20	0.78	1.83	0.410	0.95	0.58	1.57	0.842
Mother ethnicity (reference: White British)								
Pakistani	0.75	0.49	1.13	0.170	0.70	0.41	1.21	0.203
Other	0.96	0.54	1.70	0.886	0.76	0.38	1.52	0.441
Mother country of birth (reference: UK)								
Not Born UK	0.88	0.58	1.33	0.537	1.14	0.67	1.93	0.637
Means-tested benefits (reference: no)								
In receipt	0.70	0.46	1.05	0.081	0.92	0.59	1.42	0.695
IMD 2010 (reference: not most deprived quintile) Most materially deprived neighbourhood	0.78	0.53	1.16	0.223	0.99	0.63	1.53	0.951
Mother education (reference: below A-level)								
A-level or above	2.12	1.43	3.14	<0.001	2.05	1.34	3.14	0.001

Autism diagnosis in relation to socioeconomic and maternal education status

Having established the association between autism diagnosis and child/ mother characteristics we now focus on the association between autism diagnosis and maternal socioeconomic and education status. The results reported in table 3 suggest that it is education status, rather than the other measures of individual poverty or neighbourhood material deprivation, that has a substantive effect on the likelihood of a child having an autism diagnosed recorded. Children whose mothers were educated to A-level or above being around twice as likely to have a diagnosis of autism compared to children of mothers educated to below A-level; the odds ratio in the multivariate model being 2.1 (95% CI: 1.3, 3.1). The size of this effect is similar in the univariate model when considered in isolation, suggesting that the effect of mother education status is independent of the other covariates considered. In the univariate models, children of mothers in receipt of means-tested benefits and children living in more materially deprived neighbourhoods are less likely to have a diagnosis of autism. However the differences are relatively small and not statistically significant and become close to zero in a multivariate model when considered along with mother education status. To aid the interpretation of these effect sizes marginal effects, estimated prevalence rates, are calculated based on the most parsimonious model (retaining only statistically significant covariates and controlling for child age). Overall the rate of autism diagnosis was 1.0% (95% CI: 0.8%, 1.2%), similar for all children regardless of age at the date of GP extract. The prevalence for children of mother educated to A-level or above is 1.5% (95% CI: 1.1%, 1.9%) and for children of mother educated to below A-level is 0.7% (95% CI: 0.5%, 0.9%). These differences are illustrated in figure 2.

Figure 2: Predicted probability of autism diagnosis by mother education status



Estimating the potential underdiagnosis of autism in Bradford

It is possible to translate these effect sizes into levels of potential underdiagnosis of childhood autism in the population under study. The Born in Bradford cohort represents 55% of all 25,500 births at Bradford Royal Infirmary during the period 2007-2011, and is broadly representative of this wider population (Wright et al 2013). If we assume that rates are similar across different levels of maternal education then it is possible to hypothesise that there is underdiagnosis in children of mothers with lower education status and estimate the potential size of this underdiagnosis. Table 4 indicates that, of the 25,500 children born at Bradford Royal Infirmary between the

years 2007 and 2011, around 100 children of mothers with lower levels of education status will receive a diagnosis of autism by the age of five to eight years of age. Although fewer children were born to mothers with higher levels of education status more of this group will have received an autism diagnosis, around 150 children. If we apply the prevalence rates of 1.5% observed for children of higher education mothers to the population of children of lower education mothers then there may be around 115 children born at Bradford Royal Infirmary during the four year period 2007 to 2011, who have autism but are not diagnosed. Applying the lower bound of the estimate (which is similar to the 1.1% average) suggests an underdiagnosis count of around 90 children over the four year period.

Table 4: Estimated underdiagnosis of autism among children born at Bradford Royal Infirmary 2007 – 2011 (population n = 25,500)

	Mother education Below A-level (60% of population, n = 15,300)	**Mother education A-level or above level (40% of population, n = 10,200)**
Observed prevalence of autism diagnosis	0.71% (0.50% - 0.92%)	1.46% (1.10% - 1.83%)
Observed number of autism cases diagnosed	109 (77 – 141)	149 (112 – 187)
Estimated underdiagnosis of autism: Based on assumption low education status should be 1.5% (1.1%, 1.8%)	115 (92 – 139)	

* The estimated under-diagnosis of autism is calculated by multiplying the number of children in the low mother education group by the prevalence observed in the higher mother education group; then subtracting the number that are observed to be diagnosed.

Discussion

The aim of this paper was to contribute towards the understanding of potential inequalities in the diagnosis of children with autism in the UK, examining the relationship between diagnosis and socioeconomic status and potential underdiagnosis of children from lower socioeconomic backgrounds. By linking primary care records of children with data from mothers in the Born in Bradford cohort this analysis is well placed to address the research aims. These data were used to examine the occurrence of diagnosis in the primary care records and then, through the application of logistic regression models, to estimate the probability of having a diagnosis for autism recorded. These models enabled the estimation of independent effects of socioeconomic variables while also controlling for a range of other variables that influence autism diagnosis.

It was found that the education status of the child's mother, rather than income status (as measured by whether the mother was receiving means-tested benefits) or neighbourhood material deprivation (as measured by the 2010 IMD), was strongly associated with the likelihood of a child having a diagnosis of autism recorded in their primary care records. The size of this effect is substantial. Children of mothers with higher education status (A-level or above) were twice as likely to have a diagnosis of autism recorded when compared to children of mother with lower levels of education. The findings replicate those reported in a study of children in South Thames conducted over a decade ago (Baird et al 2006), which found similar associations between higher parental education status and higher rates of autism diagnosis.

These results support the argument, outlined in the introduction, that levels of service provision and inequity are important contexts when understanding inequalities in autism diagnosis. In the UK there is clear potential for inequality in autism diagnosis; given the situation where service provision is limited and potentially difficult to access, where in order to get to a diagnosis of autism parents-carers need to be aware of the potential for their child to have autism, be engaged with the health care system, be able to access information, navigate through service provision options while advocating and demanding access to diagnosis and service provision to support their child.

Of the other variables considered in the analysis only gender was statistically significant. Rates of autism diagnosis were between three and four times higher for boys than for girls. This is in line with consistently reported differences from other studies (Wing 1981, Fombonne 2009), though a recent large systematic review and meta-analysis reports that the gender difference is likely to be closer to three times, rather than four times, higher in boys (Loomes et al 2017). There were some ethnic differences observed, with children of ethnic minority mothers having lower levels of autism diagnosis recorded. This is in contrast to previous research in the UK which suggested that rates of autism are higher for ethnic minority children (Keen et al 2010), though it should be noted that the study by Keen et al reported significant differences for Black ethnic groups, while differences for South Asian groups were not statistically significant. The results also suggest that prevalence of autism in children may be increasing over time, though with the data it is not possible to determine whether this is due to increasing prevalence or earlier diagnosis. Also the number of children at each age at the data extract with recorded diagnosis at each

age of their life is small, therefore the differences observed, and illustrated in figure 1, can only be taken as indicative.

The results presented here suggest that around 100 or more children of lower education status mothers born at Bradford Royal Infirmary between 2007 and 2011 will have autism that is not diagnosed by the time they reach five to eight years of age. This is a substantial number compared to around 250 children who will have had autism correctly diagnosed by that age. Bradford's multi-ethnic and materially disadvantaged population is typical of many of the UK's major cities, therefore similar findings may be found in other areas of the UK with similar populations and similar levels of service provision. However there is the need for further research to establish the extent of this situation in the UK as a whole.

The major strength of this study lies in utilising the Born in Bradford research cohort and harnessing data linkages with routine health care records. However, there are a number of limitations that need discussion. One limitation is that, despite the large cohort, the numbers with autism in the study was still fairly small, at just 128 children. This is not necessarily a problem for the analysis presented here in terms of socioeconomic variables, as the effect size of mother education status was large enough for this sample size to detect these differences as statistically significant and the effect size of individual socioeconomic status (means-tested benefits status and neighbourhood material deprivation) were effectively zero in the multivariate models, after controlling for mother's education status. However with some other variables there may be inadequate power to determine the statistical significance of observed results. It is also important to acknowledge that the analysis presented here cannot

determine whether the differences observed in early diagnosis are maintained as children get older, whether these differences still exist by the time they reach adulthood. It may be that children with mothers of higher education status get diagnosed earlier but that by the time they are adults the differences have reduced or disappeared. This cannot be determined in this study, but it can be investigated in longer term follow up of the cohort.

We believe that the results presented here make a compelling case for the existence of socioeconomic inequalities in the diagnosis of autism for children in Bradford. The same situation may exist in other cities with similar population demographics and, to varying degrees, in the UK as a whole. If it is the case that these social-economic differences in autism diagnosis in the UK exist then what is to be done? Clearly there are resource issues that need to be addressed. In addition there have also been calls for routine screening as a way to directly address this inequity in autism diagnosis (Baird et al 2006, Janvier et al 2016). The benefits of early diagnosis of autism have been established (Sigafoos et al 2016), so tackling this inequality in diagnosis is important. While there is an argument that screening for autism can only be effective if effective interventions are available (Williams and Brayne 2006, Mandell and Mandy 2015) this argument focusses on health service interventions. Even with restricted health service provision there may be strong arguments for screening and early identification of autism for children in the pre-school and early school years as the potential for education support may exist. Any screening programme would need to be sensitive to potential cultural differences in understanding the symptoms and behaviour associated with autism (Tek and Landa 2012). It is known that disadvantage accumulates over a person's life time and early

intervention may be central to tackling this disadvantage (Marmot & Bell 2012). In this context support to children with autism in the crucially important early school years could impact to reduce further inequalities and disadvantage.

In conclusion, this study provides evidence of socioeconomic inequalities in the diagnosis of autism within children in the UK, specifically in relation to maternal education status. The size of the problem may be substantial, the implications for children's outcomes, now and as they grow older, are potentially very serious. Tackling inequalities in autism diagnosis amongst children will require action, which could include increased awareness and early screening programmes, but of central importance is the provision of adequately resourced and accessible services to ensure that children with autism, and their parents-carers, are provided with early diagnosis and timely support.

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References

American Psychiatric Association (2013) *Diagnostic and statistical manual of mental disorders (5th ed.).* Arlington, VA: American Psychiatric Publishing.

Baird G, Simonoff E, Pickles A, Chandler S, Loucas T, Meldrum D and Charman T (2006) Prevalence of disorders of the autism spectrum in a population cohort of children in South Thames: the Special Needs and Autism Project (SNAP). *The Lancet,* 368(9531): 210-215.

Bentley TE, Price C and Brown PJB (1996) Structural and lexical features of successive versions of the Read Codes. *In Proceedings of the Annual Conference of the Primary Health Care Specialist Group*. Worcester: PHCSG (pp. 91-103).

Boat TF and Wu JT (2015) *Prevalence of Autism Spectrum Disorder.* Social Sciences and National Academies of Sciences Engineering and Medicine, Washington (DC): National Academies Press (US). Available at: www.ncbi.nlm.nih.gov/books/NBK332896/ (accessed 1st March 2017).

Brett D, Warnell F, McConachie H and Parr JR (2016) Factors affecting age at ASD diagnosis in UK: no evidence that diagnosis age has decreased between 2004 and 2014. *Journal of Autism and Developmental Disorders 46*(6): 1974-1984.

Crane L, Chester JW, Goddard L, Henry LA and Hill E (2016) Experiences of autism diagnosis: A survey of over 1000 parents in the United Kingdom. *Autism* 20(2): 153-

162.

Crowe BHA and Salt AT (2015) Autism: the management and support of children and young people on the autism spectrum (NICE Clinical Guideline 170). *Archives of Disease in Childhood - Education and Practice* 100(1): 20-23.

CDC (2014) Prevalence of autism spectrum disorders among children aged 8 years: autism and developmental disabilities monitoring network, 11 sites, United States, 2010. *MMWR Surveillance Summaries* 63(2): 1–22.

DCLG (Department for Communities and Local Government) (2011)
The English indices of deprivation, 2010
http://www.communities.gov.uk/publications/corporate/statistics/indices2010
(accessed 9th May 2017)

Dickerson AS, Rahbar MH, Pearson DA, Kirby RS, Bakian AV, Bilder DA, Harrington RA, Pettygrove S, Zahorodny WM, Moyé LA and Durkin M (2017) Autism spectrum disorder reporting in lower socioeconomic neighborhoods. *Autism* 21(4): 470-480.

Durkin MS, Maenner MJ, Meaney FJ, Levy SE, DiGuiseppi C, Nicholas JS, Kirby RS, Pinto-Martin JA and Schieve LA (2010) Socioeconomic inequality in the prevalence of autism spectrum disorder: evidence from a US cross-sectional study. *PLoS One* 5(7): p.e11551.

Elsabbagh M, Divan G, Koh YJ, Kim YS, Kauchali S, Marcín C, Montiel-Nava C, Patel V, Paula CS, Wang C and Yasamy MT (2012) Global prevalence of autism and

other pervasive developmental disorders. *Autism Research* 5(3): 160-179.

Fombonne E (2009) Epidemiology of pervasive developmental disorders. *Pediatric Research* 65 (6): 591–598.

Fountain C, King MD and Bearman PS (2011) Age of diagnosis for autism: individual and community factors across 10 birth cohorts. *Journal of Epidemiology and Community Health* 65(6): 503-510.

Green H, McGinnity A, Meltzer H, Ford T and Goodman R (2005) *Mental Health of Children and Young People in Great Britain, 2004.* London: Palgrave MacMillan.

Grundy E and Holt G (2001) The socioeconomic status of older adults: How should we measure it in studies of health inequalities? *Journal of Epidemiology and Community Health* 55(12): 895-904.

Hrdlicka M, Vacova M, Oslejskova H, Gondzova V, Vadlejchova I, Kocourkova J, Koutek J and Dudova I (2016) Age at diagnosis of autism spectrum disorders: is there an association with socioeconomic status and family self-education about autism? *Neuropsychiatric Disease and Treatment* 12: 1639-1644.

Iacobucci G (2016) Public health - the frontline cuts begin. *British Medical Journal:* 352:i272 (published online 20 January 2016).

Janvier YM, Harris JF, Coffield CN, Louis B, Xie M, Cidav Z and Mandell DS (2016) Screening for autism spectrum disorder in underserved communities: Early childcare

providers as reporters. *Autism* 20(3): 364-373.

Kanner L (1943) Autistic disturbances of affective contact. *Nervous Child* 2: 217-250.

Keen DV, Reid FD and Arnone D (2010) Autism, ethnicity and maternal immigration. *The British Journal of Psychiatry* 196(4): 274-281.

Larsson HJ, Eaton WW, Madsen KM, Vestergaard M, Olesen AV, Agerbo E, Schendel D, Thorsen P and Mortensen PB (2005) Risk factors for autism: perinatal factors, parental psychiatric history, and socioeconomic status. *American Journal of Epidemiology* 161(10): 916-925.

Last JM (2007) *A Dictionary of Public Health.* New York: Oxford University Press.

Loomes R, Hull L and Mandy WPL (2017) What Is the Male-to-Female Ratio in Autism Spectrum Disorder? A Systematic Review and Meta-Analysis. *Journal of the American Academy of Child & Adolescent Psychiatry* 56(6): 466-474.

Mandell D and Mandy W (2015) Should all young children be screened for autism spectrum disorder? *Autism* 19(8): 895-896.

Marmot M and Bell R (2012) Fair society, healthy lives. *Public Health* 126(supplement 1): S4-S10.

NHS Digital (2017) Read code classification system details.

https://digital.nhs.uk/article/1104/Read-Codes (accessed 25th July 2017)

Pickard KE and Ingersoll BR (2015) Quality versus quantity: The role of socioeconomic status on parent-reported service knowledge, service use, unmet service needs, and barriers to service use. *Autism* 20(1): 106-115.

Platt L (2007) *Poverty and Ethnicity in the UK.* York: Joseph Rowntree Foundation.

Rai D, Lewis G, Lundberg M, Araya R, Svensson A, Dalman C, Carpenter P and Magnusson C (2012) Parental socioeconomic status and risk of offspring autism spectrum disorders in a Swedish population-based study. *Journal of the American Academy of Child and Adolescent Psychiatry 51*(5): 467-476.

Rice CE, Rosanoff M, Dawson G, Durkin MS, Croen LA, Singer A and Yeargin-Allsopp M (2012) Evaluating changes in the prevalence of the autism spectrum disorders (ASDs). *Public Health Reviews* 34(2): 1-22.

Robinson D, Comp D, Schulz E, Brown P and Price C. (1997). Updating the Read Codes: User-interactive Maintenance of a Dynamic Clinical Vocabulary. *Journal of the American Medical Informatics Association* 4(6): 465–472.

Sandin S, Schendel D, Magnusson P, Hultman C, Surén P, Susser E, Grønborg T, Gissler M, Gunnes N, Gross R and Henning M (2016) Autism risk associated with parental age and with increasing difference in age between the parents. *Molecular Psychiatry* 21(5): 693-700.

Schieve LA, Tian LH, Baio J, Rankin K, Rosenberg D, Wiggins L, Maenner MJ, Yeargin-Allsopp M, Durkin M, Rice C and King L (2014) Population attributable fractions for three perinatal risk factors for autism spectrum disorders, 2002 and 2008 autism and developmental disabilities monitoring network. *Annals of Epidemiology* 24(4): 260-266.

Segen JC (2006) *Concise Dictionary of Modern Medicine (2nd edition).* New York: McGraw-Hill.

Sigafoos J and Waddington H (2016) 6 year follow-up supports early autism intervention. *The Lancet*, *388*(10059): 2454-2455.

Smith N and Middleton S (2007) *A Review of Poverty Dynamics Research in the UK.* York: Joseph Rowntree Foundation.

StataCorp (2013). Stata Statistical Software: Release 13. College Station, TX: StataCorp LP.

Sun X, Allison C, Auyeung B, Baron-Cohen S and Brayne C (2014) Parental concerns, socioeconomic status, and the risk of autism spectrum conditions in a population-based study. *Research in Developmental Disabilities* 35(12): 3678-3688.

Tackey ND, Barnes H and Khambhaita P (2011) *Poverty, Ethnicity and Education.* York: Joseph Rowntree Foundation

Taylor B, Jick H and MacLaughlin D (2013) Prevalence and incidence rates of autism in the UK: time trend from 2004–2010 in children aged 8 years. *BMJ Open 3*(10): p.e003219.

Tek S and Landa RJ (2012) Differences in autism symptoms between minority and non-minority toddlers. *Journal of Autism and Developmental Disorders* 42(9): 1967-1973.

Thomas P, Zahorodny W, Peng B, Kim S, Jani N, Halperin W and Brimacombe M (2012) The association of autism diagnosis with socioeconomic status. *Autism* 16(2): 201-213.

Weintraub K (2011) Autism counts. *Nature* 479(7371): 22-24.

Williams J and Brayne C (2006) Screening for autism spectrum disorders: what is the evidence? *Autism* 10(1):11-35.

Wing L (1981) Sex ratios in early childhood autism and related conditions. *Psychiatry Research* 5(2): 129-137.

Wright J, Small N, Raynor P, Tuffnell D, Bhopal R, Cameron N, Fairley L, Lawlor DA, Parslow R, Petherick ES and Pickett KE (2013) Cohort profile: the Born in Bradford multi-ethnic family cohort study. *International Journal of Epidemiology* 42(4): 978-991.

Zaroff CM and Uhm SY (2012) Prevalence of autism spectrum disorders and influence of country of measurement and ethnicity. Social *Psychiatry and Psychiatric Epidemiology* 47(3): 395-398.

Supplementary material 1: Read (CTV3) codes for autism

Read (CTV3) code	Read (CTV3) code description	Number of times recorded in GP data extract for cohort
X00TM	Autistic spectrum disorder	102
XE2v2	Childhood autism	49
XabEY	Under care of autism assessment service	5
X00TN	Atypical autism	4
E1400	Active infantile autism	3
X00TP	Asperger syndrome	1

164 Read codes identified for 128 children. Some children have more than one Read code (for example, all those recorded as “under the care of autism assessment service” had a code for “Autism spectrum disorder” or “Childhood autism”).

Supplementary material 2: Child age at autism diagnosis and cumulative prevalence rate by age group

2a: Age of child at GP data extract and age of diagnosis of autism

	Age of child first autism recorded in GP records							
Age at GP extract	**Two**	**Three**	**Four**	**Five**	**Six**	**Seven**	**Eight**	**Total**
Five	0	10	6	6				**22**
Six	1	7	14	11	4			**37**
Seven	2	3	11	12	2	3		**33**
Eight	0	7	4	6	4	5	4	**30**
Nine	0	1	1	3	0	1	0	**6**
Total	**3**	**28**	**36**	**38**	**10**	**9**	**4**	**128**

2b: Cumulative prevalence rates (per hundred children)

Age at GP extract	**Two**	**Three**	**Four**	**Five**	**Six**	**Seven**	**Eight**
Five/ Six (n = 5,550)	0.018	0.324	0.685	0.991	1.063		
Seven/ Eight (n = 6,878)	0.029	0.189	0.422	0.727	0.814	0.945	1.003