Investigating the prevalence and risk factors of picky eating in a birth cohort study

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Abbreviations:
GUS - Growing up in Scotland
ASD - Autism spectrum disorder
PE - Picky eating
ARFID - Avoidant/restrictive food intake disorder
DASS-21 - Depression, Anxiety and Stress Scales
DSM-5 - Diagnostic and Statistical Manual of Mental Disorders, Fifth Edition
RRR - Relative Risk Ratio

Abstract

This study aimed to investigate the prevalence of childhood picky eating (PE) and to identify risk factors associated with different PE trajectories using data from the Growing up in Scotland research survey. PE was operationalised using three items across three study sweeps, at ages 2, 5 and 10 years respectively. We found 13.5% of children with PE at age 2, 22.2% at age 5, and 6.4% at age 10. From these, we defined three PE categories: transient PE in early childhood (23.3%), persistent PE into late childhood (3.7%) and PE absent (73.0%). Using multinomial logistic regression, we investigated associations between child and family characteristics and transient and persistent PE, adjusting for potential confounders. Various factors were associated with increased risk of persistent pickiness, including mothers who smoked during pregnancy and children whose mothers reported feeding challenges at 9-12 months. These findings support the view that PE behaviours are common and tend to remit by adolescence although a small number of children are at risk of experiencing longer term problems. Families of children who are exposed to such risks may benefit from preventative interventions.

Keywords: picky eating; fussy eating; Avoidant/Restrictive Food Intake Disorder; child; childhood eating behaviors; autism spectrum disorder; longitudinal study

1. Introduction

The term picky eating (PE) refers to a range of restrictive eating behaviours. While there is currently no universally agreed definition for PE, it is often characterised by limited interest in food or enjoyment of eating, rejection of specific foods and or new foods, slowness in eating, or strong preferences for certain foods or preparation methods.[1-4]

PE is often regarded as a common phase of development, which peaks in early childhood.[5-10] Although it can be a concerning time for parents, such behaviours are often transient and there is no evidence to date which suggests that this affects development or physical health. Therefore, it is rarely necessary to conceptualise them as problematic. However, PE can pose risks to longer term health and development if characterised by intake of an inadequate variety or amount of food and if persisting into late childhood and adolescence.[11,12] In such cases, PE can be classified as disordered, potentially warranting a diagnosis of avoidant/restrictive food intake disorder (ARFID), a clinical eating disorder that describes severe or prolonged restriction of the volume and or variety of food leading to disruptions in weight/growth trajectories, nutritional deficiencies and or psychosocial impairment.[13]

Findings of existing studies suggest that children with PE have stronger likes and dislikes and less acceptance of new foods,[14] and tend to consume fewer calories[15]. Some evidence also indicates that children with PE have a lower weight compared to children without PE,[16,17] although findings have been mixed[11]. Evidence also shows that the incidence[14] and prevalence[6] of PE declines across childhood and that PE is a persistent phenomenon only in a small proportion of children. For instance, a cohort study of 4018 children found that 27.6% experienced PE at age 3 years, but only 13.2% had PE three years later.[6]

Previous studies have evidenced several associated risk factors for persisting PE. These include maternal negative affect, early feeding challenges, lower socioeconomic status, and developmental delay.[6,16,18-20] Further, persisting PE has been found to be more common in males, in children with a lower birth weight and in those with mothers from ethnic minority groups.[6] Feeding challenges in the first year of life can also be indicative of different issues. For example, early feeding difficulties may present as a risk factor for later concerns, particularly if worried parents feel the need to use force or coercion with food, leading to the development of negative associations with food and mealtimes.[21] Alternatively, they could be an early marker of longer term or inherent issues, such as sensory sensitivities or a low appetite.[22]

Understanding risk factors associated with persistent PE could lead to a better understanding of their aetiology and the development of preventative interventions. Nevertheless, research is limited, has rarely followed children until late childhood, and has not investigated important correlates such as autism diagnoses, and factors relating to pregnancy and birth. To address these limitations, this study has the following aims:

1. To classify participants according to PE status: those who experience PE for a short period (transient PE in early childhood); those who experience PE for a prolonged period (persistent PE into late childhood); and those who never experience PE (PE absent).
2. To investigate the prevalence of transient PE in early childhood and persistent PE into late childhood.
3. To identify the child and family characteristics associated with different PE profiles.

2. Method

2.1. Sample

Growing up in Scotland (GUS) is a national longitudinal birth cohort study carried out by ScotCen Social Research on behalf of the Scottish Government.

We used data from the first GUS birth cohort, or BC1, a nationally representative cohort of families with children born between June 2004 and May 2005 randomly sampled from those living in Scotland and in receipt of a universal child benefit (97% of the Scottish population). Data were collected annually when the children were around 10 months old up until 6 years of age, and then biennially thereafter. When there was more than one eligible child per household, GUS selected one child at random. We also excluded data from respondents who were non birth mothers[i], as several variables related to pregnancy and birth, and therefore, were most reliably taken from those who had given birth to the study child.

In this study, we described sample characteristics and estimated prevalence of PE behaviours among participants with complete outcome data. We conducted our main analyses on all GUS participants meeting our inclusion criteria, imputing any missing exposure or outcome data.

The Scotland 'A' MREC committee (application reference: 04/M RE 1 0/59) gave ethical approval. Further details on the GUS cohort are available at https://growingupinscotland.org.uk/.

2.2. Outcomes

2.2.1. Picky eating

Given the lack of a universally accepted definition or measure of assessment,[10] there is great variability in the measurement of PE. We operationalised the outcome variable using three items across three study sweeps.

[i] Non birth mother refers to caregivers who did not give birth to the study child (i.e., adoptive/foster mothers, fathers, grandparents, etc)

At age 2 and 5, parents were asked, "How would you describe the variety of foods that [child] generally eats? Does she/he: (1) Eat most things, (2) Eat a reasonable variety of things, or (3) is she/he a fussy eater?". We classified children with PE if parents answered (3). A similar question was used in a previous study by Mascola et al.[14]

Since the above question was not given to participants in sweep 8, we chose the following item to identify children with PE at age 10, "At the main meal, is [child] served different food from adults? (1) Never, (2) Occasionally, (3) Quite often, or (4) Mostly." We classified children with PE if parents answered (4). This draws on the definition of PE posited by Dubois et al[16] as children who always eat a different meal to other members of the family.

We considered children with PE at either 2 or 5 years (or both), but not at 10 years as those with transient PE in early childhood (hereafter, transient PE) and those with PE at either 2 or 5 years (or both) and also at 10 years, as those with persistent PE into late childhood (hereafter, persistent PE). We captured PE at age 2 and or age 5, when food fussiness is considered relatively common. We felt that PE at either or both of these time points that no longer posed a problem at age 10, could indicate this common phase (i.e., transient PE). Conversely, since children have emerged from 'early childhood' by age 10, any persisting PE behaviours may be indicative of a pervasive issue or underlying eating disorder (i.e., ARFID).

2.3. Exposures

We considered a number of maternal, child and demographic factors previously suggested as risk factors for PE as exposures.[4-6,18,23-26] These included socioeconomic position (as indexed by maternal education and household income), pregnancy- and birth-related factors (smoking and alcohol consumption during pregnancy, birth weight [in grams], pre-term birth), maternal stress and depression (each measured with three items from the DASS-21[27] (full item list in eTable 1), the presence of an autism diagnosis, and measures of

problematic feeding at 0-3 and 9-12 months. Data on all variables were collected via self-report from the child's birth mother, and the majority at sweep 1, thereby ensuring that the exposure preceded the measurement of the outcome and limiting the potential for reverse causation (see supplementary eTable 2 for a full list of variables used and the sweep they were measured at).

A measure of autism spectrum disorder (hereafter, autism) was aggregated at ages 5, 6, 7, 10 and 12. Mothers were asked 'Has child additional support needs?' and if so, required to select from a list, with 'Autistic Disorder' as one option. Children whose mothers replied yes to this question at least once across the five sweeps were noted as autistic, providing that there were no contradictory responses thereafter. If mothers said yes and then no at a later sweep, autism was not recorded. As a sensitivity analysis to increase statistical power, we also defined children as autistic if the mother said yes at any of the sweeps, regardless of any subsequent contradictory report.

2.4. Data analysis

All statistical analyses were conducted using Stata release 17.[28] We describe prevalence of PE and describe sample characteristics using frequencies and proportions.

In our main analyses, we imputed missing exposure and outcome data using multiple imputation by chained equations, imputing 50 data sets. Imputation models included all variables in the analyses (outcomes and exposures) and a number of auxiliary variables hypothesised to be associated with missingness to improve precision of imputation (i.e., mother's self-reported general health - see eTable 2 for further detail).

In this imputed sample, to investigate the association between exposures and transient or persistent PE, we used univariable and multivariable multinomial logistic regressions. For all models, we report relative risk ratios, 95% confidence intervals (CI), and p-values. Relying on binary interpretations of p-values (i.e., using 0.05 as a threshold for statistical

significance) could increase risks of type I and II errors, the latter being a key concern in the presence of uncommon exposure/outcome combinations resulting in low statistical power. To minimise this risk, we jointly used 95% CI and p-values - viewed as a continuum of probability - to reflect on the strength of the evidence against the null hypothesis in the context of each model, as recommended by the literature.[29] Generally, p-values exceeding 0.1 are taken to indicate increasingly weaker evidence in support of the null-hypothesis; p-values between 0.1 and 0.001 indicate increasingly strong evidence against the null-hypothesis; and p-values below 0.001 indicate very strong evidence against the null-hypothesis.

We first ran univariable models for each of the exposures under investigation. Subsequently, we ran multivariable models adjusting each variable for potential confounders of its association with the outcome (PE status). We defined confounders as factors which could have caused both the exposure and the outcome and could not have been on the causal pathway between the two. For instance, we adjusted child's birth weight for gestational age, as prematurely born babies will likely have a lower birth weight than those born at term.

To further assess the robustness of our findings, a number of sensitivity analyses were conducted. We calculated the prevalence of PE at each study sweep with the sample including non-birth mothers and conducted univariable and multivariable logistic regression models using complete case analyses (participants with complete data on all outcome and exposure variables). We also coded any child as autistic with at least one record of autism and assessed the association between picky eating status and an autism diagnosis.

We only present unadjusted relative risk ratios for both child sex and child ethnicity as neither can be affected by external influences. Table 1 provides a full list of exposures and confounding variables used for each of these.

[Insert Table. 1]

3. Results

3.1. Sample characteristics

A total of 5217 children were enrolled in GUS BC1, 5144 (98.6%) of whom had their birth mother as main respondent. Among this sample, 2498 (48.6%) were female and 4916 (95.6%) white. Most mothers were aged between 30-39 years at the birth of the cohort child (49.4%) and 72.3% had achieved educational qualifications beyond those which are compulsory in Scotland (Table 2).

[Insert Table. 2]

Among these children, 2957 (57.5%) had data on PE behaviours available at ages 2, 5, and 10 years (and thus available data on the PE outcome) and of these, 2604 (50.6%) also had data available on all exposure variables. We compared the distribution of sociodemographic characteristics between participants with complete data on all variables of interest (n=2604, 50.6%) and those who had some missing data on exposures or outcomes (n=2540, 49.4%). A greater proportion of males (49.8%) and children from ethnic minority backgrounds (68.0%) had some missing data compared to females (49.0%) and children of white ethnicity (48.5%). Missing data was also more common among children born to mothers with compulsory educational qualifications only (66.2%) and younger mothers (under 20 years at birth of cohort child; 75.6%) compared to those whose mothers had continued with further education (42.8%) and those who were 30-39 years when they gave birth (40.0%) (full detail in eTable 3).

3.2. Picky eating behaviours

Using all available cohort data, 13.5%, 22.2%, and 6.4% of children at ages 2, 5, and 10 years respectively, displayed PE behaviours. A total of 798 (27.0%) children had PE behaviours at either 2 or 5 years, or both. Of these, 689 (86.3%) no longer had PE behaviours at age 10 years and 109 (13.7%) also displayed PE behaviours at age 10 years. We considered

the former as having transient PE (23.3% of the total sample) and the latter as having persistent PE (3.7% of the total sample).

3.3. Risk factors for picky eating

Results for the univariable and multivariable regression models (N=5144) are presented in Table 3. Below we report results of multivariable models only.

3.3.1. Child socio-demographic characteristics

Compared to males, there was weak and no evidence that females were at lower risk of persistent (relative risk ratio [RRR]: 0.73, 95% confidence interval [CI]: 0.48-1.10) and transient PE (RRR: 0.90, 95%CI: 0.75-1.08), respectively. There was evidence that children from minority ethnic backgrounds had greater risk of experiencing transient PE compared to white children (RRR:1.55, 95%CI: 0.98-2.44), and only weak evidence of differences in persistent PE (RRR: 1.79, 95%CI: 0.78-4.10).

3.3.2. Family Socio-economic/demographic characteristics

Children whose mothers had only completed compulsory education had higher risk of both transient and persistent PE behaviours compared to those whose mothers had remained in education beyond the age of 16 years with evidence of a dose-response association ([transient]RRR:0.77, 95%CI: 0.62-0.96, [persistent]RRR:0.46, 95%CI: 0.30-0.70). Children with younger mothers had higher risk of experiencing transient PE (RRR:0.97, 95%CI: 0.96-0.98), however, we only found weak evidence of an association with greater risk of persistent PE (RRR:0.98, 95%CI: 0.94-1.01). Greater income was associated with lower risk of transient (RRR:0.86, 95%CI: 0.76-0.98) and persistent PE (RRR:0.73, 95%CI: 0.56-0.95).

3.3.3. Pre-natal risk factors

There was evidence that children of mothers who smoked during their pregnancy were at greater risk of persistent PE compared to those whose mothers did not smoke at all (RRR:2.18, 95%CI: 1.34-3.57), but we only observed a weak association with transient PE

(RRR:1.21, 95%CI: 0.93-1.57). There was no evidence of an association between maternal alcohol consumption in pregnancy and child PE ([transient]RRR:0.97, 95%CI: 0.79-1.19; [persistent] RRR:0.73, 95%CI: 0.42-1.29).

3.3.4. Perinatal risk factors

Babies who were delivered with medical intervention were at greater risk than those born via vaginal delivery to experience persistent PE (RRR:1.52, 95%CI: 1.02-2.26), but not transient PE (RRR:1.09, 95%CI: 0.90-1.31). Premature birth was not associated with transient (RRR:0.86, 95%CI: 0.63-1.18) or persistent PE (RRR:0.88, 95%CI: 0.50-1.55). Similarly, we found weak evidence that children born later than their due date were at lower risk of experiencing transient (RRR:0.81, 95%CI: 0.60-1.08) and persistent PE (RRR:0.58, 95%CI: 0.31-1.09). Admission to a special care baby unit was not associated with transient PE (RRR:1.08, 95%CI: 0.81-1.44) but there was weak evidence of an association with lower risk of persistent PE (RRR:0.49, 95%CI: 0.21-1.13).

There was no evidence of an association between lower birth weight and transient (RRR:0.95, 95%CI: 0.86-1.04) or persistent PE (RRR:0.94, 95%CI: 0.76-1.17).

3.3.5. Maternal mental health

There was weak evidence of an association between greater symptoms of maternal stress and increased risk of transient PE (RRR:1.05, 95%CI: 0.99-1.12) but no evidence of an association with persistent PE (RRR:1.07, 95%CI: 0.91-1.25).

Greater depressive symptoms in the mother were not associated with increased risk of child transient (RRR:1.03, 95%CI: 0.96-1.11) and only a weak association was found with persistent PE (RRR:1.11, 95%CI: 0.95-1.29).

3.3.6. Child factors

Feeding challenges in the first year were associated with greater risk of later PE. Children whose mothers reported concerns at 0-3 months were at increased risk of displaying

transient (RRR:1.32, 95%CI: 1.06-1.65) but not persistent PE (RRR:1.14, 95%CI: 0.69-1.89). Children whose mothers had feeding concerns at 9-12 months were at greater risk of experiencing both transient (RRR:2.40, 95%CI: 1.88-3.06) and persistent PE (RRR:2.04, 95%CI: 1.20-3.46). Older age at introduction of solid foods was not associated with transient (RRR:0.98, 95%CI: 0.91-1.06) or persistent PE (RRR:1.02, 95%CI: 0.83-1.24).

There was weak evidence that children of mothers who reported concerns regarding their development, learning and behaviour were at increased risk of persistent PE (RRR:1.60, 95%CI: 0.82-3.12) but no evidence was found for transient PE (RRR:1.11, 95%CI: 0.78-1.59). We found weak evidence of an association between autism and greater risk of persistent PE (RRR:1.97, 95%CI: 0.72-5.41), but no evidence of an association with transient PE (RRR:1.09, 95%CI: 0.60-1.96).

[Insert Table. 3]

3.4. Sensitivity analyses

Results of all sensitivity analyses did not differ qualitatively from that of the main analyses. See eTable 4, eTable 5 and eTable 6.

4. Discussion

This study is one of very few to examine the prevalence and risk factors of PE behaviours in a cohort of young children. We found that PE was most common at age 5, but this remitted for the majority of children by age 10 years. Though prevalence estimates vary, our findings support those of previous studies which show that PE is often a typical phase of childhood development[6,8,30] and that PE behaviours tend only to persist beyond this stage for a small number of children.

We identified a number of factors which were associated with PE presentations. For example, our data suggest that both transient and persistent PE are associated with lower socioeconomic status. While this does not warrant confirmation of a specific risk factor, it

calls for increased attention to be paid to those who may have greater difficulties and could benefit from support, for example, school talks given to parents in deprived areas to deliver education around feeding practices and information about access to clinical services and support.

We found some evidence that males appear to be at greater risk of PE than females, which is consistent with earlier work.[6] Autism was also found to be associated with PE, albeit with some statistical uncertainty. Since the literature suggests that autism is more prevalent, or at least more commonly diagnosed in males than in females,[31] it may point to shared aetiological mechanisms between autism and PE. Indeed, feeding and eating difficulties including food selectivity, sensory preferences, and rituals regarding preparation and or presentation are a commonly cited concern for parents of autistic children.[32-34] Clinically, it is important to know that co-morbidities between PE and autism may exist and therefore, children presenting with either should be screened for both in order to ensure appropriate access to care.

We also found a greater risk of PE in children whose mothers smoked in pregnancy, which again could point to aetiological mechanisms. Whilst general population studies have previously linked smoking in pregnancy to autism in offspring,[35,36] studies using genetically informed designs have found this association to be largely confounded by underlying genetic risk.[37,38] More research is therefore needed to disentangle whether the association that we observed between smoking in pregnancy and PE is causal.

While this study has several strengths including the use of a large longitudinal dataset with frequent assessment of the same cohort of participants over an extended period, there are some limitations to consider. First, the GUS study exclusively sampled children born in Scotland between 2004 and 2005, 97% of which were white families. Hence, the findings may have limited generalisability to other populations. This may also explain why the

analyses did not identify a strong association for ethnicity as we may not have had adequate statistical power to accurately test for this.

We were also limited by the data provided in the GUS study. Assessment of symptoms was based on parent report and therefore rooted in the observations and perceptions of parents and carers, as opposed to the child's own experience. Further, there is no agreed definition for PE, or gold standard for the assessment of symptoms, so the main outcome for this study was operationalised using a single item posed to respondents at three study sweeps. While this is a limitation, it is consistent with prior research,[30,39] and questions were selected from the GUS dataset that closely mirrored previous studies which assessed PE behaviours.[14,16] Relatedly, GUS included a different question at age 10 compared to those asked at ages 2 and 5. Although previous research supports the use of this question at age 10 as a useful indicator of PE,[16] our measure could have resulted in the misclassification of some participants and potentially, in the over- or underestimation of prevalence of PE. We were nevertheless reassured as our estimates are in line with those of previous studies.[6,14]

While there were some sociodemographic differences between the sample of participants with all outcome and exposure data compared to those with some missing, we were reassured to observe that the results of sensitivity analyses using complete cases were compatible with those of the main models using imputed data, although the latter provided more precise estimates (indexed by narrower 95% confidence intervals) likely due to increased statistical power given the larger sample size.

Despite larger than those of most previous studies, our sample might have still been underpowered to detect differences for a number of less common putative risk factors for which we only found weak associations. To account for this, we have interpreted our results in terms of strength of associations rather than relying on strict p-value cut offs. Studies with larger samples are warranted in order to replicate these findings.

Finally, our definition of autism relied on receipt of a diagnosis by age 12. As such, it may have missed children diagnosed after school entry or in secondary school, and those who will not receive a diagnosis. As there is evidence that certain groups (i.e., girls, children from more deprived backgrounds) are more likely to be underdiagnosed in childhood,[30] this could have biased our estimates if these groups also differed in terms of PE. Our estimates of autism prevalence are nevertheless in line with current evidence.[40] It is also important to note the possible implications of using this particular exposure, namely reverse causation, where the outcome can make the exposure more likely. Children with PE behaviours may visit doctors or other healthcare professionals more often than those with adequate food intake, to monitor their weight and or nutritional status. Children who are autistic and have PE behaviours might have a greater chance of receiving a diagnosis of autism, as an indirect result of regular contact with healthcare professionals and services. This might result in overestimating the association under study. We did observe an increased risk of PE for autistic children, although 95% CIs were wide and included the null. Nevertheless, other general population studies and genetically informed designs have shown that autistic children are at a greater risk of selective eating,[41] so our findings, although underpowered, are in line with previous literature.

4.1. Conclusion

PE is common throughout childhood but there is little understanding of the trajectories of early food fussiness. We have identified a number of risk factors for persistent PE and some that are shared with more transient presentations.

Though not sufficiently definitive to inform actual changes in clinical care for young people presenting with eating disorders, the findings do generate a number of population level implications relating to aetiology and prevention. Further work is now needed to distinguish between PE and PE associated with clinically significant impairment to health and

day-to-day functioning, which is a key feature of ARFID. There is also a need to better understand whether persistent PE is associated with adverse physical or mental health outcomes as, to date, this is an under-researched area. A clearer understanding of the causes and outcomes of persistent PE would help elucidate aetiological pathways and achieve a better understanding of the clinical needs of this population.

Table 1. Confounding structure of risk factors used in regression models

	Risk factors	**Confounders**
1. Child socio-demographic characteristics	Child sex	-
	Child ethnicity	-
2. Family socio-economic/demographic characteristics	Mother's highest education level	Maternal age (at birth of cohort child)
	Maternal age (at birth of cohort child)	Highest education level
	Household income	Maternal age (at birth of cohort child) Highest education level
3. Pre-natal risk factors	Smoking during pregnancy	"Family socio-economic/demographic characteristics" Alcohol pregnancy
	Alcohol consumption during pregnancy	"Family socio-economic/demographic characteristics" Smoking pregnancy
4. Perinatal risk factors	Type of delivery	"Family socio-economic/demographic characteristics" "Pre-natal risk factors" Gestational age
	Child's gestational age	"Family socio-economic/demographic characteristics" "Pre-natal risk factors" Type of delivery
	Child birth weight in grams (standardised)	"Family socio-economic/demographic characteristics" "Pre-natal risk factors" Gestational age Type of delivery
	Did child spend any time in a special baby unit?	"Family socio-economic/demographic characteristics" "Pre-natal risk factors" Type of delivery Gestational age Birth weight in grams (standardised)
5. Maternal mental health	DASS Stress[ii]	"Family socio-economic/demographic characteristics" "Pre-natal risk factors" "Perinatal risk factors" DASS Depression

[ii] Depression Anxiety Stress Scales - Stress measure taken from Sweep 2

Table 1. (continued) Confounding structure of risk factors used in regression models

	Risk factors	**Confounders**
	DASS Depression[iii]	"Family socio-economic/demographic characteristics" "Pre-natal risk factors" "Perinatal risk factors" DASS Stress
6. Child factors	Feeding problems 0-3 months	"Family socio-economic/demographic characteristics" "Pre-natal risk factors" "Perinatal risk factors" "Maternal mental health" Child ethnicity Concerns regarding development
	Feeding problems 9-12 months	"Family socio-economic/demographic characteristics" "Pre-natal risk factors" "Perinatal risk factors" "Maternal mental health" Child ethnicity Feeding problems 0-3 months Concerns regarding development
	Age at introduction of solid food (months)	"Family socio-economic/demographic characteristics" "Pre-natal risk factors" "Perinatal risk factors" "Maternal mental health" Child ethnicity Feeding problems 0-3 months Feeding problems 9-12 months Concerns regarding development
	Concerns regarding development	"Family socio-economic/demographic characteristics" "Pre-natal risk factors" "Perinatal risk factors" "Maternal mental health"
	Autism[iv]	"Family socio-economic/demographic characteristics" "Pre-natal risk factors" "Perinatal risk factors" "Maternal mental health" Child sex Concerns regarding development

[iii] Depression Anxiety Stress Scales - Depression measure taken from Sweep 2
[iv] Variable derived from questions at Sweeps 5, 6, 7, 8 and 9

Table 2. Sample characteristics (N=5144)

	Participants with complete data (outcomes and exposures) N(%)	Picky eating absent n(%)	Transient picky eating n(%)	Persistent picky eating n(%)
Total	5144 (100%)	2159 (73.0%)	689 (23.3%)	109 (3.7%)
Child sex				
Male	2646 (51.4%)	1081 (71.8%)	360 (23.9%)	64 (4.3%)
Female	2498 (48.6%)	1078 (74.2%)	329 (22.7%)	45 (3.1%)
Child ethnicity				
White	4916 (95.6%)	2099 (73.4%)	656 (23.0%)	103 (3.6%)
Other ethnic background	225 (4.4%)	60 (61.2%)	32 (32.7%)	6 (6.1%)
Mother's highest education level				
Compulsory[v]	1421 (27.7%)	369 (65.5%)	159 (28.3%)	35 (6.2%)
Non-compulsory	3711 (72.3%)	1788 (74.8%)	530 (22.2%)	73 (3.0%)
Maternal age (at birth of cohort child)*				
Under 20	349 (6.8%)	63 (63.6%)	30 (30.3%)	6 (6.1%)
20-29	2072 (40.3%)	753 (73.8%)	234 (22.9%)	33 (3.2%)
30-39	2540 (49.4%)	1260 (73.3%)	396 (23.0%)	64 (3.7%)
40 or older	182 (3.5%)	83 (70.3%)	29 (24.6%)	6 (5.1%)
Household income*				
Up to £11,999	1033 (22.4%)	266 (66.7%)	111 (27.8%)	22 (5.5%)
£12,000-£22,999	1137 (24.6%)	443 (68.5%)	173 (26.7%)	31 (4.8%)
£23,000-£31,999	865 (18.7%)	401 (72.3%)	134 (24.1%)	20 (3.6%)
£32,000-£42,999	991 (21.5%)	532 (77.8%)	133 (19.4%)	19 (2.8%)
£50,000 or more	591 (12.8%)	319 (77.8%)	81 (19.8%)	10 (2.4%)

[v] In Scotland, education is not compulsory after Standard Grade exams at age 16 (considered to be equivalent to GCSEs)

Table 2. (continued) Sample characteristics (N=5144)

	Participants with complete data (outcomes and exposures) N(%)	Picky eating absent n(%)	Transient picky eating n(%)	Persistent picky eatin n(%
Total	5144 (100%)	2159 (73.0%)	689 (23.3%)	109 (3.7%
Smoking pregnancy				
No	3876 (75.9%)	1795 (74.8%)	534 (22.3%)	70 (2.9%
Yes (occasionally/always)	1232 (24.1%)	353 (64.9%)	153 (28.1%)	38 (7.0%
Alcohol pregnancy				
No	3716 (73.3%)	1496 (72.1%)	495 (23.9%)	83 (4.0%
Yes (occasionally/always)	1352 (26.7%)	639 (75.4%)	185 (21.8%)	24 (2.8%
Type of delivery				
Vaginal delivery	3159 (61.8%)	1284 (73.3%)	413 (23.6%)	55 (3.1%
With medical intervention[vi]	1953 (38.2%)	858 (72.3%)	274 (23.1%)	54 (4.6%
Child's gestational age				
On time	707 (13.8%)	280 (69.8%)	104 (25.9%)	17 (4.3%
Early	2125 (41.4%)	876 (72.2%)	284 (23.4%)	53 (4.4%
Late	2303 (44.9%)	1000 (74.7%)	300 (22.4%)	39 (2.9%
Low birth weight*				
No	4802 (93.5%)	2029 (73.0%)	647 (23.3%)	103 (3.7%
Yes	336 (6.5%)	129 (72.9%)	42 (23.7%)	6 (3.4%
Special care baby unit				
No	4548 (88.4%)	1939 (73.2%)	610 (23.0%)	101 (3.8%
Yes	595 (11.6%)	220 (71.7%)	79 (25.7%)	8 (2.6%

[vi] 'With medical intervention' comprises forceps, Ventouse suction, forceps and Ventouse, caesarean section before labour began, caesarean section after labour began, or other.

Table 2. (continued) Sample characteristics (N=5144)

	Participants with complete data (outcomes and exposures) N(%)	Picky eating absent n(%)	Transient picky eating n(%)	Persistent picky eating n(%)
Total	5144 (100%)	2159 (73.0%)	689 (23.3%)	109 (3.7%)
Feeding problems 0-3 months				
Not a problem	4261 (82.9%)	1790 (73.9%)	543 (22.4%)	89 (3.7%)
A problem (a bit or big)	882 (17.1%)	368 (68.9%)	146 (27.3%)	20 (3.8%)
Feeding problems 9-12 months				
Not a problem	4443 (86.4%)	1929 (75.5%)	537 (21.0%)	88 (3.5%)
A problem (a bit or big)	701 (13.6%)	230 (57.1%)	152 (37.7%)	21 (5.2%)
Age at introduction of solid food (months)				
0-3	329 (12.6%)	259 (71.5%)	88 (24.3%)	15 (4.2%)
4-7	2244 (86.2%)	1855 (73.5%)	581 (23.0%)	89 (3.5%)
8-10	31 (1.2%)	22 (61.1%)	11 (30.6%)	3 (8.3%)
Concerns about child's development, learning and behaviour?				
No concerns	4768 (92.7%)	2024 (73.3%)	640 (23.2%)	97 (3.5%)
Yes (some or a lot)	373 (7.3%)	134 (68.7%)	49 (25.1%)	12 (6.2%)
Does child have additional needs? (Autism)				
No	3452 (97.8%)	2122 (73.2%)	673 (23.2%)	103 (3.6%)
Yes	79 (2.2%)	37 (62.7%)	16 (27.1%)	6 (10.2%)

[*]Note. We display this categorical variable for the purpose of presenting clear sample characteristics. A continuous measure is used in the regression analyses
[**] Some columns do not total 5144 due to missing data
[***] Picky eating data is available on n=2957. Totals of individual variables may not add up to 2957 due to missing data

Table 3. Univariable and multivariable logistic regression model results for the association between picky eating status and child and maternal variables using imputed data (N=5144)

	Picky eating status			
	Transient	**Persistent**	**Transient**	**Persistent**
Variable	**Univariable model, Relative Risk Ratio (95% CI[vii]); p value**		**Multivariable model, Relative Risk Ratio (95% CI); p value**	
Child sex				
Male	Reference	Reference	-	-
Female	0.90 (0.75-1.08); 0.245	0.73 (0.48-1.10); 0.129	-	-
Child ethnicity				
White	Reference	Reference	-	-
Other ethnic background	1.55 (0.98-2.44); 0.061	1.79 (0.78-4.10); 0.160	-	-
Highest education level				
Compulsory	Reference	Reference	Reference	Reference
Non-compulsory	0.68 (0.55-0.83); 0.001	0.41 (0.28-0.61); 0.000	0.77 (0.62-0.96); 0.023	0.46 (0.30-0.70); 0.001
Maternal age (at birth of cohort child)	0.96 (0.95-0.98); 0.000	0.95 (0.92-0.99); 0.007	0.97 (0.96-0.98); 0.000	0.98 (0.94-1.01); 0.154
Household income (std)	0.78 (0.71-0.86); 0.000	0.63 (0.51-0.79); 0.000	0.86 (0.76-0.98); 0.020	0.73 (0.56-0.95); 0.021
Smoking pregnancy				
No	Reference	Reference	Reference	Reference
Yes (occasionally/always)	1.49 (1.16-1.90); 0.003	2.84 (1.86-4.33); 0.000	1.21 (0.93-1.57); 0.147	2.18 (1.34-3.57); 0.003
Alcohol pregnancy				
No	Reference	Reference	Reference	Reference
Yes (occasionally/always)	0.88 (0.72-1.07); 0.189	0.67 (0.39-1.15); 0.189	0.97 (0.79-1.19); 0.762	0.73 (0.42-1.29);0.272

[vii] Confidence intervals

Table 3. (continued) Univariable and multivariable logistic regression model results for the association between picky eating status and child and maternal variables using imputed data (N=5144)

	Picky eating status			
	Transient	**Persistent**	**Transient**	**Persistent**
Variable	**Univariable model, Relative Risk Ratio (95% CI[viii]); p value**		**Multivariable model, Relative Risk Ratio (95% CI); p value**	
Type of delivery				
Vaginal delivery	Reference	Reference	Reference	Reference
With medical intervention	0.96 (0.81-1.14); 0.652	1.31 (0.91-1.87); 0.138	1.09 (0.90-1.31); 0.366	1.52 (1.02-2.26); 0.038
Gestational age				
Early	0.88 (0.65-1.20); 0.396	0.98 (0.56-1.73); 0.950	0.86 (0.63-1.18); 0.336	0.88 (0.50-1.55); 0.649
On time	Reference	Reference	Reference	Reference
Late	0.82 (0.61-1.10); 0.168	0.61 (0.33-1.14); 0.118	0.81 (0.60-1.08); 0.147	0.58 (0.31-1.09); 0.086
Birth weight (std)				
	0.92 (0.84-1.01); 0.065	0.80 (0.65-0.97); 0.027	0.95 (0.86-1.04); 0.264	0.94 (0.76-1.17); 0.557
Special care baby unit				
No	Reference	Reference	Reference	Reference
Yes	1.19 (0.91-1.56); 0.201	0.78 (0.35-1.71); 0.518	1.08 (0.81-1.44); 0.581	0.49 (0.21-1.13); 0.092
DASS Stress				
	1.08 (1.03-1.14); 0.002	1.18 (1.04-1.33); 0.010	1.05 (0.99-1.12); 0.110	1.07 (0.91-1.25); 0.398
DASS Depression				
	1.11 (1.05-1.17); 0.001	1.24 (1.11-1.37); 0.000	1.03 (0.96-1.11); 0.400	1.11 (0.95-1.29); 0.191
Feeding 0-3 months				
Not a problem	Reference	Reference	Reference	Reference
A problem (a bit or big)	1.31 (1.06-1.62); 0.014	1.12 (0.69-1.83); 0.626	1.32 (1.06-1.65); 0.014	1.14 (0.69-1.89); 0.603

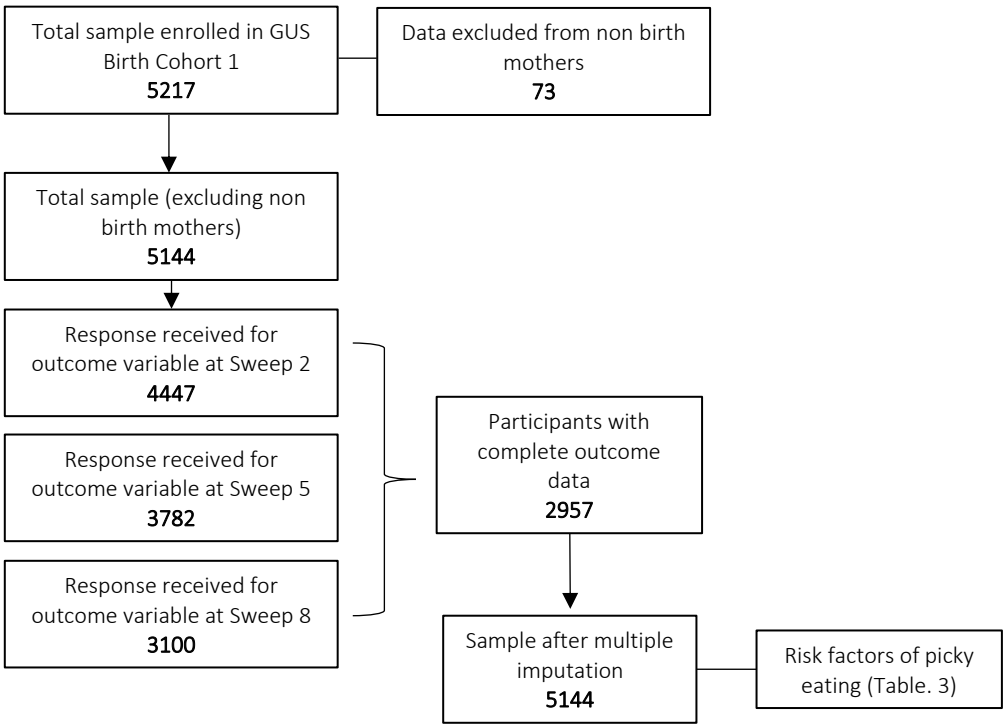
[viii] Confidence intervals

Table 3 (continued) Univariable and multivariable logistic regression model results for the association between picky eating status and child and maternal variables using imputed data (N=5144)

	Picky eating status			
	Transient	**Persistent**	**Transient**	**Persistent**
Variable	**Univariable model, Relative Risk Ratio (95% CI[ix]); p value**		**Multivariable model, Relative Risk Ratio (95% CI); p value**	
Feeding 9-12 months				
Not a problem	Reference	Reference	Reference	Reference
A problem (a bit or big)	2.34 (1.84-2.97); 0.000	1.90 (1.13-3.21); 0.018	2.40 (1.88-3.06); 0.000	2.04 (1.20-3.46); 0.010
Months old - solid food				
	0.96 (0.89-1.04); 0.339	0.97 (0.78-1.20); 0.753	0.98 (0.91-1.06); 0.692	1.02 (0.83-1.24); 0.877
Development concerns				
No concerns	Reference	Reference	Reference	Reference
Concerns (some or a lot)	1.21 (0.85-1.71); 0.284	1.84 (0.96-3.55); 0.066	1.11 (0.78-1.59); 0.547	1.60 (0.82-3.12); 0.160
Autism				
No	Reference	Reference	Reference	Reference
Yes	1.40 (0.79-2.49); 0.243	3.16 (1.19-8.36); 0.023	1.09 (0.60-1.96); 0.775	1.97 (0.72-5.41); 0.176

[ix] Confidence intervals

Figure 1. Flow chart of study participation



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Author Contributions

- Laura Bourne conceptualised and designed the study, drafted the initial manuscript, and led the data analysis, interpretation of findings and manuscript writing.
- Professor Mandy contributed to the conceptualisation and design of the study, data analysis and reviewed and revised the manuscript.
- Dr Bryant-Waugh contributed to the conceptualisation and design of the study, data analysis and reviewed and revised the manuscript.
- Dr Solmi contributed to the conceptualisation and design of the study, supervised data analysis and interpretation of results, and reviewed and revised the manuscript.
- All authors approved the final manuscript as submitted and agree to be accountable for all aspects for the work.

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eSupplement

Table of Contents

eTable 1. Items taken from the Depression, Anxiety and Stress Scales – 21 (Lovibond & Lovibond, 1995) to measure maternal mental health

GUS Variable Name	Variable Description
MbHdas01	I found myself getting upset by quite trivial things (stress)
MbHdas02	I found it difficult to relax (stress)
MbHdas03	I felt that I had nothing to look forward to (depression)
MbHdas04	I felt sad and depressed (depression)
MbHdas05	I found that I was very irritable (stress)
MbHdas06	I was unable to become enthusiastic about anything (depression)

1 = Did not apply to me at all
2 = Applied to me to some degree, or some of the time
3 = Applied to me a considerable degree, or a good part of the time
4 = Applied to me very much, or most of the time

eTable 2. Summary of measures used across study sweeps

Variable Description	GUS Variable Name	GUS Sweep
Does child eat variety of foods	MbFvar01	2
Does child eat variety of foods	M2Fvar01	5
At the main meal is child served different food from adults	MhFsam02	8
Sex of study child	MaHGsx1	1
Ethnicity of child	DaEthGpC	1
Highest education level of respondent	DaMedu01	1
Age of natural mother at birth of cohort child	DaHGmag5	1
Total income band of your household from all sources before tax - including benefits, interest	MaWinc09	1
During your pregnancy with child did you smoke cigarettes	MaHcig01	1
Thinking back to when you were pregnant with child, which of these best describes how often you usually drank then (alcohol)	MaHalc04	1
What type of delivery did you have	MaBdel01	1
Was child born early, late or on time	MaBtim01	1
Birth weight in grams	DaWgGr	
Did child spend any time in a Special Care Baby Unit (SCBU) or a Neo-Natal Unit after he/she was born	MaBneo01	1
DASS Stress Score (0-9)	DbHdas01	2
DASS Depression Score (0-9)	DbHdas02	2
In the first 3 months how much of a problem was - getting child to feed	MaTfed01	1
In the last 3 months how much of a problem is - getting child to feed or eat	MaTfed02	1
How many months old was child when he/she first started solid food	MaFsol02	1
Do you have any concerns about child s development, learning or behaviour	MaHdev01	1
Has child additional support needs?	MePSan01	5
- Add needs - autistic disorder	MePSan09	5
Has child additional support needs?	MfPSan01	6
- Add needs - autistic disorder	MfPSan09	6
Has child additional support needs?	MgPSan01	7
- Add needs - autistic disorder	MgPSan09	7
Has child additional support needs?	MhPSan01	8
- Add needs - autistic disorder	MhPSan09	8
Has child additional support needs?	MiPSan01	9
- Add needs - autistic disorder	MiPSan09	9
Thinking about your pregnancy with [child] as a whole, would you say you generally kept…	MaPGht01 **(AUXILIARY)**	1
Thinking about the first six weeks or so after child was born, how well do you think you and [child's] mother/father, as a couple, dealt with the arrival of your child?	MaPcop01 **(AUXILIARY)**	1
How is child s health in general?	MaHgen01 **(AUXILIARY)**	1
Does child have any health problems or disabilities that have lasted or are expected to last for more than a year?	MaHlsi01 **(AUXILIARY)**	1
In general, would you say your health is excellent, very good, good, fair, or poor	MaHpgn01 **(AUXILIARY)**	1

eTable 3. Comparison of sample characteristics for participants with complete data (n=2604) and those with missing outcome and/or exposure data (n= 2540) among the total sample of Growing Up in Scotland Children with birth mother as main respondent

	Complete cases	Some missing exposure and/or outcome data
	n(%)	n(%)
Total	2604 (50.6%)	2540 (49.4%)
Child sex		
Male	1329 (50.2%)	1317 (49.8%)
Female	1275 (51.0%)	1223 (49.0%)
Child ethnicity		
White	2532 (51.5%)	2384 (48.5%)
Other ethnic background	72 (32.0%)	153 (68.0%)
Mother's highest education level		
Compulsory	481 (33.8%)	940 (66.2%)
Non-compulsory	2123 (57.2%)	1588 (42.8%)
Maternal age (at birth of cohort child)*		
Under 20	85 (24.4%)	264 (75.6%)
20-29	904 (43.6%)	1168 (56.4%)
30-39	1523 (60.0%)	1017 (40.0%)
40 or older	92 (50.5%)	90 (49.5%)
Household income*		
Up to £11,999	376 (36.4%)	657 (63.6%)
£12,000 - £22,999	628 (55.2%)	509 (44.8%)
£23,000 - £31,999	534 (61.7%)	331 (38.3%)
£32,000 - £42,999	672 (67.8%)	319 (32.2%)
£50,000 or more	394 (66.7%)	197 (33.3%)
Smoking pregnancy		
No	2139 (55.2%)	1737 (44.8%)
Yes (occasionally/always)	465 (37.7%)	767 (62.3%)
Alcohol pregnancy		
No	1847 (49.7%)	1869 (50.3%)
Yes (occasionally/always)	757 (56.0%)	595 (44.0%)
Type of delivery		
Vaginal delivery	1551 (49.1%)	1608 (50.9%)
With medical intervention	1053 (53.9%)	900 (46.1%)
Child's gestational age		
On time	355 (50.2%)	352 (49.8%)
Early	1072 (50.4%)	1053 (49.6%)
Late	1177 (51.1%)	1126 (48.9%)
Low birth weight*		
No	2448 (51.0%)	2354 (49.0%)
Yes	156 (46.4%)	180 (53.6%)

eTable 3. (continued) Comparison of sample characteristics for participants with complete data (n=2604) and those with missing outcome and/or exposure data (n= 2540) among the total sample of Growing Up in Scotland Children with birth mother as main respondent

	Complete cases	**Some missing exposure and/or outcome data**
	n(%)	**n(%)**
Total	2604 (50.6%)	2540 (49.4%)
Feeding problems 9-12 months		
Not a problem	2263 (51.0%)	2180 (49.0%)
A problem (a bit or big)	341 (48.6%)	360 (51.4%)
Age at introduction of solid food (months)		
0-3	329 (42.3%)	448 (57.7%)
4-7	2244 (53.2%)	1974 (46.8%)
8-10	31 (44.3%)	39 (55.7%)
Concerns about child's development, learning and behaviour?		
No concerns	2441 (51.2%)	2327 (48.8%)
Yes (some or a lot)	163 (43.7%)	210 (56.3%)
Does child have additional needs? (Autism Spectrum Disorder; ASD)		
No	2553 (74.0%)	899 (26.0%)
Yes	51 (63.6%)	28 (35.4%)

*Note. We display this categorical variable for the purpose of presenting clear sample characteristics. A continuous variable is used in the regression analyses.

eTable 4. Prevalence of picky eaters at each study sweep (sample including non birth mothers)

	Count	Percent
Sweep 2 (age 2) (n = 4507)	610	13.5
Sweep 5 (age 5) (n = 3829)	847	22.1
Sweep 8 (age 10) (n = 3143)	205	6.5

eTable 5. Univariable and multivariable logistic regression model results for the association between picky eating status and child and maternal variables using complete case analysis (n = 2604)

	Picky eating status			
	Transient	**Persistent**	**Transient**	**Persistent**
Variable	**Univariable model, Relative Risk Ratio (95% CI); p value**		**Multivariable model, Relative Risk Ratio (95% CI); p value**	
Child sex				
Male	Reference	Reference	-	-
Female	0.89 (0.73-1.09); 0.263	0.73 (0.47-1.15); 0.168	-	-
Child ethnicity				
White	Reference	Reference	-	-
Other ethnic background	1.50 (0.87-2.58); 0.143	2.17 (0.78-6.09); 0.136	-	-
Highest education level				
Compulsory	Reference	Reference	Reference	Reference
Non-compulsory	0.69 (0.55-0.86); 0.001	0.48 (0.28-0.80); 0.006	0.77 (0.60-0.98); 0.036	0.52 (0.29-0.92); 0.026
Maternal age (at birth of cohort child)	0.97 (0.95-0.98); 0.000	0.96 (0.93-0.99); 0.021	0.97 (0.95-0.99); 0.001	0.98 (0.95-1.01); 0.186
Household income (std)	0.80 (0.73-0.88); 0.000	0.67 (0.52-0.85); 0.001	0.87 (0.78-0.98); 0.026	0.72 (0.52-0.99); 0.042
Smoking pregnancy				
No	Reference	Reference	Reference	Reference
Yes (occasionally/always)	1.44 (1.16-1.79); 0.001	2.92 (1.87-4.57); 0.000	1.18 (0.94-1.48); 0.161	2.41 (1.43-4.06); 0.001
Alcohol pregnancy				
No	Reference	Reference	Reference	Reference
Yes (occasionally/always)	0.89 (0.70-1.13); 0.314	0.77 (0.46-1.27); 0.298	0.97 (0.76-1.23); 0.771	0.80 (0.47-1.35);0.398
Type of delivery				
Vaginal delivery	Reference	Reference	Reference	Reference
With medical intervention	0.95 (0.80-1.13); 0.545	1.48 (1.04-2.12); 0.030	1.06 (0.88-1.27); 0.557	1.67 (1.14-2.46); 0.010
Gestational age				
Early	0.79 (0.60-1.05); 0.108	1.01 (0.49-2.06); 0.988	0.80 (0.59-1.08); 0.136	0.96 (0.46-2.01); 0.912
On time	Reference	Reference	Reference	Reference
Late	0.74 (0.57-0.96);0.026	0.65 (0.33-1.25);0.190	0.74 (0.57-0.97); 0.032	0.65 (0.33-1.27); 0.206

eTable 5. (continued) Univariable and multivariable logistic regression model results for the association between picky eating status and child and maternal variables using complete case analysis (n = 2604)

	Picky eating status			
	Transient	**Persistent**	**Transient**	**Persistent**
Variable	**Univariable model, Relative Risk Ratio (95% CI); p value**		**Multivariable model, Relative Risk Ratio (95% CI); p value**	
Birth weight (std)	0.92 (0.83-1.02); 0.128	0.80 (0.64-0.99); 0.043	0.94 (0.83-1.05); 0.265	0.93 (0.75-1.16); 0.521
Special care baby unit				
No	Reference	Reference	Reference	Reference
Yes	1.11 (0.82-1.52); 0.490	0.72 (0.28-1.82); 0.481	1.02 (0.71-1.46); 0.920	0.43 (0.17-1.12); 0.082
DASS Stress	1.07 (1.01-1.13); 0.024	1.18 (1.01-1.37); 0.033	1.04 (0.98-1.10); 0.207	1.11 (0.92-1.34); 0.290
DASS Depression	1.10 (1.03-1.17); 0.004	1.22 (1.08-1.37); 0.002	1.03 (0.96-1.11); 0.421	1.05 (0.89-1.24); 0.561
Feeding 0-3 months				
Not a problem	Reference	Reference	Reference	Reference
A problem (a bit or big)	1.35 (1.05-1.73); 0.019	1.00 (0.59-1.71); 0.989	1.39 (1.07-1.80); 0.014	1.01 (0.59-1.74); 0.969
Feeding 9-12 months				
Not a problem	Reference	Reference	Reference	Reference
A problem (a bit or big)	2.36 (1.84-3.03); 0.000	2.08 (1.16-3.72); 0.015	2.42 (1.85- 3.16); 0.000	2.13 (1.22- 3.73); 0.009
Months old - solid food	0.95 (0.88-1.02); 0.143	0.99 (0.83-1.19); 0.930	0.97 (0.90-1.04); 0.397	1.04 (0.87-1.25); 0.623
Concerns re development				
No concerns	Reference	Reference	Reference	Reference
Concerns (some or a lot)	1.08 (0.74-1.59); 0.672	1.75 (0.86-3.55); 0.122	1.05 (0.72-1.55); 0.784	1.51 (0.78-2.92); 0.215
Autism spectrum disorder				
No	Reference	Reference	Reference	Reference
Yes	1.23 (0.62-2.46); 0.546	3.82 (1.44-10.13); 0.008	0.97 (0.49-1.92); 0.931	2.38 (0.92-6.15); 0.073

eTable 6. Univariable and multivariable logistic regression model results for the association between picky eating status and autism (coded as at least one record of autism, even with a subsequent contradictory response)

Autism spectrum disorder				
No	Reference	Reference	Reference	Reference
Yes	1.32 (0.77-2.27); 0.301	4.10 (1.94-8.66); 0.000	1.10 (0.62-1.94); 0.735	2.81 (1.36-5.81); 0.006