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Still Unequal at Birth: Birth Weight, Socio-economic Status and Outcomes at Age 9

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Abstract: The prevalence of low birth weight is an important aspect of public health which has been linked to increased risk of infant death, increased cost of care, and a range of later life outcomes. Using data from a new Irish cohort study, I document the relationship between birth weight and socio-economic status. The association of maternal education with birth weight does not appear to be due to the timing of birth or complications during pregnancy, even controlling for a wide range of background characteristics. However, results do suggest intergenerational persistence in the transmission of poor early life conditions. Birth weight predicts a number of outcomes at age 9, including test scores, hospital stays and health. An advantage of the data is that I am able to control for a number of typically unmeasured variables. I determine whether parental investments (as measured by the quality of interaction with the child, parenting style, or school quality) mediate the association between birth weight and later indicators. For test scores, there is evidence of non-linearity, and boys are more adversely affected than girls. I also consider whether there are heterogeneous effects by ability using quantile regression. These results are consistent with a literature which finds that there is a causal relationship between early life conditions and later outcomes.

I INTRODUCTION

The focus of public health authorities on low birth weight has been justified for a number of reasons; indeed it is often the target of public policy, for instance the Medicaid and WIC programmes in the US (Black *et al.*, 2007).

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First, at the individual level, reduced birth weight is an important risk factor in infant mortality; those born with a weight of less than 2,500 grams are at a greater risk of dying within their first year of life. Almond *et al.* (2005) estimate that the cost of care for a child born at 1,000 grams can be in excess of $100,000. Even for babies weighing 2,000-2,100 grams, an additional pound (454 grams) is still associated with a $10,000 difference in hospital charges. Second, a substantial literature across the social sciences, including epidemiology, economics, and psychology, has linked birth weight to a number of outcomes in later life. These include measures of health (in particular cardiovascular disease), but also education and labour market status. I review the evidence in the next section. Finally, birth weight is also relevant at the population level as a general marker of public health, as it encapsulates many different aspects which contribute to make up the well-being of society. These include factors such as education and behaviour, the efficacy of the health care system, and the level of inequality. Although health at birth itself is characterised by inequality, it is also malleable (Currie, 2011).

There have been relatively few previous studies of this topic in Ireland. Three exceptions are McAvoy *et al.* (2006), Niedhammer *et al.* (2009), and Nolan (1994). This paper uses data from a new cohort study to address two main aims. First, I examine the determinants of birth weight in Ireland. Second, I evaluate the effects of birth weight on the outcomes of children at age 9. The *Growing Up in Ireland* study (henceforth *GUI*) is a nationally representative cohort study of two groups, 8,500 nine year olds, and 11,000 nine month olds, first surveyed in 2009. In each case interviews were conducted with all primary (and where available secondary) care givers, and in the case of the 9 year cohort, data was also collected from schools (including teachers and principals), as well as interviews with the children themselves.

Although the data used in this paper do not lend themselves to fully addressing the potential for omitted variables to affect the results with an experimental or quasi-experimental identification strategy, I am able to control for a wide range of variables on family background, and typically unobserved aspects of a child's upbringing which arguably measure aspects of parental investments in their children. In particular, I examine whether the association between birth weight and later outcomes is mediated by indicators for parenting quality, parenting style, and school quality. As these factors are generally shared by twins and siblings, within-family studies cannot establish the role of these variables as mediating factors in the wider population. Combined with the findings from the previous literature (in particular those from twin and sibling comparisons), there is reason to believe that the results presented here have a causal component.

The rest of this paper is structured as follows. I provide an overview of the literature in Section II. In Section III, I summarise the relationship between socio-economic status and birth weight using the 9 month cohort. I discuss the factors across the domains of family background, maternal characteristics, and behaviour which predict weight at birth. A strong social gradient exists, and there is also evidence of intergenerational transmission of early life conditions. In Section IV, I determine whether birth weight predicts outcomes at age 9 using data from the second cohort, and in particular whether this relationship is mediated by parenting or school quality. I find that the effects of birth weight are independent of these factors. I also examine whether there is any heterogeneity in the effects of initial health by gender, and by ability, using quantile regression. Section V concludes.

II LITERATURE

There is a growing literature which examines the link between early life conditions and later life outcomes. These findings have been argued as providing a credible basis for targeting initial health (low birth weight being one measure of this) for intervention. The issue of causality is a difficult problem to address due to the potential for some omitted variable to bias estimates of the effects of early life conditions. Finding that birth weight matters for later outcomes could simply reflect the fact that it is correlated with some other component of family background, which is the true causal factor in determining later outcomes. For example, "bad" parents may have children of lower birth weight, and this may be the factor which actually influences the future status of children with poor early life health. Similarly, children of low birth weight may be more likely to attend lower quality schools, or live in poorer neighbourhoods. Genetics is another alternative explanation, however, measuring all, or even some, of these components can be difficult. Also, the bias from using OLS is not clear, at least a priori. While it is possible that birth weight is positively correlated with some other unobserved factor (resulting in an upward bias), if parents invest differentially in a twin or sibling of higher birth weight, then OLS could be biased downwards. Ideally, a source of exogenous variation in infant health could be used to establish true causal effects. Finding a natural experiment which affects only early life conditions can be difficult, however, one example of this is Almond (2006), who compares individuals exposed *in utero* to the 1918 flu pandemic to cohorts born just before, and just after. Affected cohorts are found to be worse off on a number of outcomes. Delaney *et al.* (2011) use a dramatic shift in public health which occurred in Ireland in the 1940s, and show that the children who benefited from improvements in early life conditions went on to be healthier and stronger adults. Almond and Currie (2011) provide a recent summary of the causal evidence.

An alternative strategy to address concerns about omitted variable bias is to use data on siblings or twins. This allows the researcher to control for features which are common to each sibling group (such as family background, and genetics in the case of monozygotic twins), without the need to explicitly collect information on that factor. In fact, there have been a number of papers which examine the determinants and effects of birth weight using this technique. Royer (2009) uses a database of Californian twins and finds significant (although relatively small), lasting consequences of initial health. Oreopoulus *et al.* (2008) also use a twin study, and conclude that birth weight predicts mortality up to 17 years, as well as educational and labour force outcomes. Black *et al.* (2007) find similar results for education and wages, and that results from fixed effects models for long run outcomes do not differ greatly from OLS. Behrman and Rosenzweig (2004) find comparable relationships with fixed effects models, and argue that the effects of birth weight on schooling could be underestimated by as much as 50 per cent in cross-sectional studies. Overall, despite the fact that the results from these studies tend to differ in terms of magnitude, the direction of the findings is similar. Importantly for the models presented in this paper, OLS and twin fixed effects models often give similar results. Moreover, in addition to finding that birth weight predicts future economic status, Currie and Moretti (2007) also find that there is a strong persistence in low birth weight, especially for those born in high poverty areas. Allowing for within sibling comparisons, the lasting impact of poor initial health is worse for those from disadvantaged backgrounds. The probability of being born of low birth weight is 50 per cent higher for those with mothers of low birth weight.

Several papers have also considered the role of omitted variables in infant health production functions. Although I am not able to isolate exogenous variation in the covariates in this data, one advantage of GUI is the comprehensive nature of the survey, which does include information on paternal characteristics, which are not always available in other datasets. Previous studies on Ireland have used registration data (McAvoy *et al.*, 2006; Nolan, 1994) or the Lifeways cross-generational prospective study (Murrin *et al.*, 2007; Niedhammer *et al.*, 2009). Reichman *et al.* (2009) argue that excluding typically unobserved variables, such as the father's characteristics, from infant health production functions does not substantially alter conclusions about the effects of inputs, and that single equation models of infant health production, as I adopt in this paper, can be used with confidence. In terms of the other factors which influence birth weight, Dearden *et al.*

(2011) find that length of gestation is one of the most important predictors. Tanaka (2005) finds a relationship between paid leave and low birth weight, while Rossin (2011) also finds a positive effect of maternity leave. Conley and Bennett (2000) find that maternal income does not have an important impact on birth weight, once parental birth weight is controlled for. Maternal education has also been found to have an effect on birth weight (Currie and Moretti, 2003; Chavalier and O'Sullivan, 2007).

The methodology of using within family comparisons is not open to me as I only have information on one child per family. Instead, I use the rich data available in *GUI* to control for the factors which have been identified in the literature as being important determinants of birth weight and later outcomes. A potential drawback relates to the use of self-reports (for a discussion, see Reichman *et al.*, 2009). However, using data from Northern Ireland, Walton *et al.* (2000) compare maternal reports of birth weight with linked objective data. Of parents, 85 per cent were able to recall correctly (to within a specified margin). They conclude that self-reports may be a suitable proxy, although they also find that low birth weight and high birth weight were associated with poorer recall, as was parental occupational status. If anything, using birth weight as reported by mothers may therefore have the effect of understating socioe-conomic differences. There have also been criticisms of the use of birth weight itself as a measure of infant health. Almond *et al.* (2005) examine the short-run costs of low birth weight, using a database of twins. Although the associated costs themselves are large, within twin pairs birth weight is not a predictor of infant death. However, there is little consensus about which alternatives would be more appropriate, and other measures such as APGAR scores are rarely available, at least not until relatively recently. In fact, the use of birth weight itself has not been consistent in the literature, with some papers using birth weight as a continuous measure, and others focusing only on the effects of low birth weight (less than 2,500g).

Twin comparison approaches are not without their drawbacks, for example, parental investments in their children may be a function of birth weight itself, which is a potential explanation for the downward bias of OLS results in Behrman and Rosenzweig (2004). In addition, twins typically tend to be of lower birth weight than singletons, and because twin studies implicitly compare differences in birth weight within a pair, it is problematic to draw strong conclusions about the effect of levels in the population as a whole. Differences in birth weight between twins may be small, at least relative to the overall variation in birth weight. Finally, since siblings or twins tend to attend the same schools, and have the same parents, it is not possible to determine the extent to which shared influences, such as parenting or school quality, mediate the relationship between birth weight and later outcomes in the general population. Due to the data requirements, these types of studies typically use official linked data, which rarely has the kind of detailed information on family background available in cohort studies. Nevertheless, within-family studies are a crucial tool for establishing the limitations of cross-sectional estimates, in particular in the context of omitted factors such as genetics, which are difficult, if not impossible, to measure.

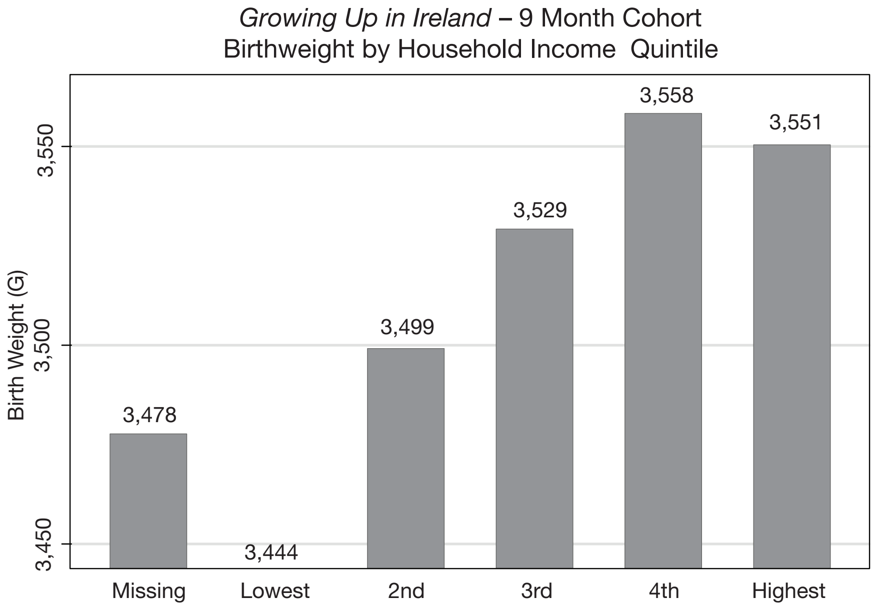
In summary, despite conflicting results in terms of the magnitude of the lasting effects of initial health, across methodologies the direction of the results is generally consistent with the idea that birth weight has important lasting consequences. In addition, OLS has been found to give similar results to fixed effects models.

III DETERMINANTS OF BIRTH WEIGHT

I begin by considering the determinants of birth weight in the 9 month cohort. In order to ensure a more homogeneous sample, I restrict the data analysis to those babies born in Ireland, whose mother was identified as the primary caregiver. I also exclude non-singleton births. For the 9 month cohort this reduces the sample from 11,134 to 10,582. There are three important factors to note about the primary variable of interest in this paper. First, mothers are asked to provide information on the weight of their babies, as part of the *GUI* main carer questionnaire. As outlined in the previous section, there is reason to believe that self-reports are reliable in this context. Second, although in theory birth weight is a continuous variable, as part of the anonymisation procedure the data have been re-coded at the top and bottom of the distribution. Those born under 1,499g are coded as "1,499 or less", those between 1,500 and 2,499g as "1,500-2,499", and those born above 4,600 grams are coded as "4,600 or above". Finally, birth weight is rounded to the nearest 100g. This type of measurement error will bias estimates of the effect of initial health downwards. When the dependent variable is censored, it is appropriate to adopt an estimation technique which takes account of this, as biased estimates could result from ignoring the fact that part of the distribution is missing from the data. I present results from a tobit where I amalgamate the bottom two categories, however, using OLS does not greatly affect the results. Weights are also provided to account for differences between the data and population which arose during the sampling procedure.

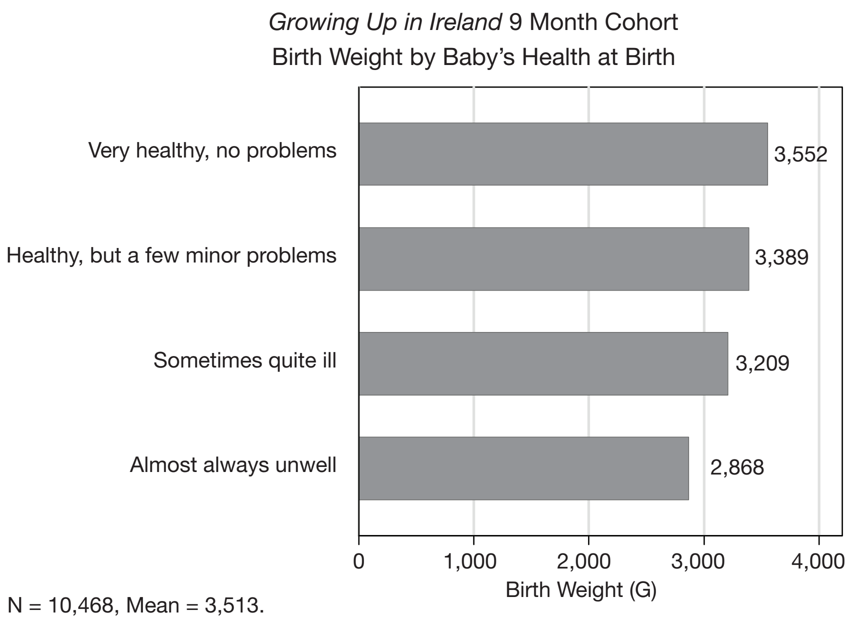
About 4 per cent of the sample are of low birth weight (under 2,500g), with the mean being 3,513g. As the variable has been censored in the data, it is not necessarily expected to match up exactly with the mean in the population.

Figure 1: *Birth Weight and Family Income (9 Month Cohort)*



N = 10,468, Mean = 3,513.

Figure 2: *Birth Weight and Baby's Health at Birth (9 Month Cohort)*



N = 10,468, Mean = 3,513.

Despite this, these figures correspond to those obtained from official records (*Perinatal Statistics Report*, 2009). There is a strong bivariate relationship between this variable and measures of socioe-conomic status, for example, Figure 1 illustrates that the mean birth weight of those born in the lowest income quintile was 3,444g, compared to 3,551g in the highest, although the relationship appears to be non-monotonic. This social gradient in birth weight is evident no matter which measure of socioe-conomic status is chosen; consistent with previous studies, it is clear from the data that initial infant health is strongly influenced by family social background. The results are not presented here due to space limitations; however I have confirmed that the social gradient in the *UK Millennium Cohort* study is almost identical. A very similar pattern is observed when looking at the prevalence of low birth weight, as opposed to this continuous measure. The coefficient on a linear fit suggests that an extra year of maternal education results in an additional 13g in terms of weight at birth for her child. Other factors such as family structure are also important; birth weight is highest in families with two parents and two or more children. An important question is whether birth weight is related to any of the other measures of initial health available in the data. Figure 2 illustrates the relationship with the mothers' reports of their babies' health at birth. There is also a correlation with sleeplessness, and developmental scores in communication, gross motor control, fine motor control, problem solving ability, and social ability at 8 months. On this basis, it seems apparent that birth weight provides an accurate reflection of initial conditions.

Table 1 presents Tobit regression results of birth weight on family characteristics, with particular emphasis on household income and parental education. For each column, I present the coefficients from the first specification only (for reasons of presentation), however, the full table with all control variables is available in the online Appendix as Table 6. The first column presents the results including only the variables present in the table as controls, namely household income and parental education, along with a quadratic in mother's age, a dummy variable taking the value 1 if the mother is over 40 (as the variable is censored at this value in the data), and the gender of the baby. The outcome is birth weight in grams, as reported by the mother. The relationship in the descriptive statistics is also present here, namely moving from the lowest income quintile to the second highest is associated with an increase in birth weight of around 58g, or about 2 per cent of the mean. Interestingly, the coefficient on the highest income quintile is not significant, so the effect appears to be non-linear. An extra year of maternal education is associated with an increase of 9g, while an extra year of paternal education is associated with an extra 6g. Father's education therefore appears to have an effect which is independent of the mother's education. Particularly

Table 1: *Determinants of Birth Weight (Summary)*

Variables	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*
Mother's Age	26.1*	18.2	18.6	1.1	6.5
	(14.115)	(14.663)	(14.288)	(12.622)	(12.390)
Mother's Age Squared	–0.3	–0.3	–0.4	–0.0	–0.1
	(0.233)	(0.240)	(0.234)	(0.207)	(0.203)
Mother Over 40	–38.4	–16.5	–19.0	–10.2	–5.0
	(33.652)	(33.451)	(33.022)	(29.725)	(30.283)
Female	–123.5***	–130.8***	–131.5***	–134.2***	–124.2***
	(12.371)	(12.295)	(12.074)	(10.930)	(10.849)
HH Income: Missing	0.6	–13.4	–7.9	–1.2	–3.2
	(29.649)	(30.408)	(29.998)	(27.009)	(26.897)
HH Income: 2nd Quintile	23.7	8.4	16.9	9.1	7.7
	(28.640)	(29.095)	(28.727)	(26.258)	(26.035)
HH Income: 3rd Quintile	39.8	33.0	33.5	22.2	16.5
	(28.150)	(28.244)	(27.908)	(25.313)	(25.025)
HH Income: 4th Quintile	57.5**	79.3***	70.5**	68.9***	62.3**
	(27.841)	(27.979)	(27.707)	(25.100)	(24.884)
HH Income: Highest	10.1	50.7*	36.7	21.7	5.8
Quintile	(28.157)	(28.619)	(28.466)	(25.558)	(25.414)
Mother Age Left Education	9.2***	11.8***	7.8***	5.6**	0.6
	(2.606)	(2.683)	(2.667)	(2.412)	(2.429)
Father Age Left Education	6.0**	8.9***	7.4***	7.4***	7.5***
	(2.521)	(2.598)	(2.578)	(2.353)	(2.347)
Father's Education Missing	73.8	161.0***	133.3**	129.4***	153.6**
	(51.560)	(54.722)	(54.226)	(49.551)	(63.660)
Observations	10,272	10,135	10,133	10,129	9,773
Extended SES Controls	No	Yes	Yes	Yes	Yes
Maternal Behaviour	No	No	Yes	Yes	Yes
Pregnancy Variables	No	No	No	Yes	Yes
Parental Height	No	No	No	No	Yes

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Note: Regressions are weighted, unweighted results are similar. The dependent variable (birth weight) is censored under 2,500g and over 4,600g. The omitted category for household income is the 1st quintile. The full table with all control variables is available in the online Appendix as Table 6. Model 1 includes only the variables present in the table. Model 2 adds controls for household social class, number of siblings, family structure, rural area, mother not born in Ireland, and neighbourhood safety problems. Model 3 adds smoking in household during pregnancy, mother received help, mother's health, mother smokes, mother drinks. Model 4 adds weeks before birth stopped working, weeks became aware of pregnancy, weeks at first ante-natal appointment, gained weight during pregnancy, timing of birth, and pregnancy complications. The final model adds parental height.

for the characteristics of the secondary caregiver, there is a relatively high proportion of individuals who were not interviewed, and therefore have missing data. For father's education, roughly 25 per cent are missing. To address this, I include a dummy variable for those who have missing data. These variables are often significant, indicating that this attrition is non-random. Due to this relatively large number, the treatment of missing values has the potential to greatly affect estimation results, and in particular, the approach of recoding missing values can lead to biased estimates (Little and Rubin, 2002). I also consider the use of multiple imputation (where missing values are inferred from the other available information in the data, for implementation see Royston, 2009), as an alternative strategy for dealing with this problem. However, I find that this has little effect on the results.

As outlined in the previous section, a key question relates to whether the observed relationship between parental education and birth weight is causal, as there may be some other omitted variable which is correlated with this measure and the true cause of low birth weight. Columns 2 and 3 add additional controls; however this has relatively little effect on the magnitude or significance of the coefficients on household income or education. Another important question relates to whether families of lower socioe-conomic status are more likely to have pregnancies with medical complications and earlier births, as this could be a potential pathway mediating the social gradient in birth weight. In column 4, I add controls for the number of weeks at which the mother became aware of the pregnancy, stopped working before the birth, and had her first ante-natal appointment. I also control for weight gain, the timing of the birth, and the presence of any complications during pregnancy. The coefficients on parental education and income are reduced to a certain extent, but they remain significant. I conclude that the social gradient in birth weight is not simply a consequence of the fact that families of lower socio-economic status are more likely to have pre-term babies, or medical complications during pregnancy. Finally, in column 5 I control for both maternal and paternal height. This is to take account of the possible intergenerational transmission of birth weight as discussed in Currie and Moretti (2007). As I do not observe the birth weight of the mother, I use measured height as a marker of early life conditions. Consistent with the results in Conley and Bennett (2000), I find that the effect of maternal education is now not significant (although the coefficients on income and paternal education are unaffected), and interpret this as evidence for persistence in initial health. Irish mothers with less education are of lower height (a proxy for worse early life conditions), which explains at least part of the relationship between their educational attainment and the birth weight of their own children. This does not rule out the potential for maternal education to have an independent effect. The other

Table 2: *Other Significant Determinants of Birth Weight*

Variables	*Coefficient*
Number of Siblings in Household	19.1**
	(9.690)
HH Type: Parent 1 Child	–106.1***
	(38.148)
HH Type: 2 Parents 1 Child	–133.4***
	(18.114)
Rural Area	24.1**
	(11.288)
Someone in HH Smoked During Pregnancy	–28.9**
	(13.517)
Family not living in the country	–112.4***
	(25.961)
Mother's health: Poor	–132.0*
	(69.831)
Mother Smokes: Occasionally	126.7***
	(23.723)
Mother Smokes: Not at all	180.8***
	(17.437)
Weeks before birth mother stopped working	9.5***
	(2.295)
Weeks before birth mother stopped working NA	46.3**
	(18.998)
Gained weight during pregnancy (kilos)	12.2***
	(1.041)
Birth Timing: Very early (32 weeks or less)	–1,272.7***
	(82.856)
Birth Timing: Somewhat early (33-36 weeks)	–719.9***
	(32.691)
Birth Timing: Late birth (42 weeks or more)	228.5***
	(16.776)
No Pregnancy Complications	55.9***
	(10.913)

Robust standard errors in parentheses.
*** $p<0.01$, ** $p<0.05$, * $p<0.1$.
Note: Regressions are weighted, unweighted results are similar. This table shows the coefficient on significant variables in the final specification of Table 1. The full table with all control variables is available in the online Appendix as Table 6. The omitted category for household type is "2 parents and 2 or more children", for the mother's family not living in the country the omitted category is "mother gets enough help", for maternal health the omitted category is "excellent health", and for birth timing the omitted category is "on time."

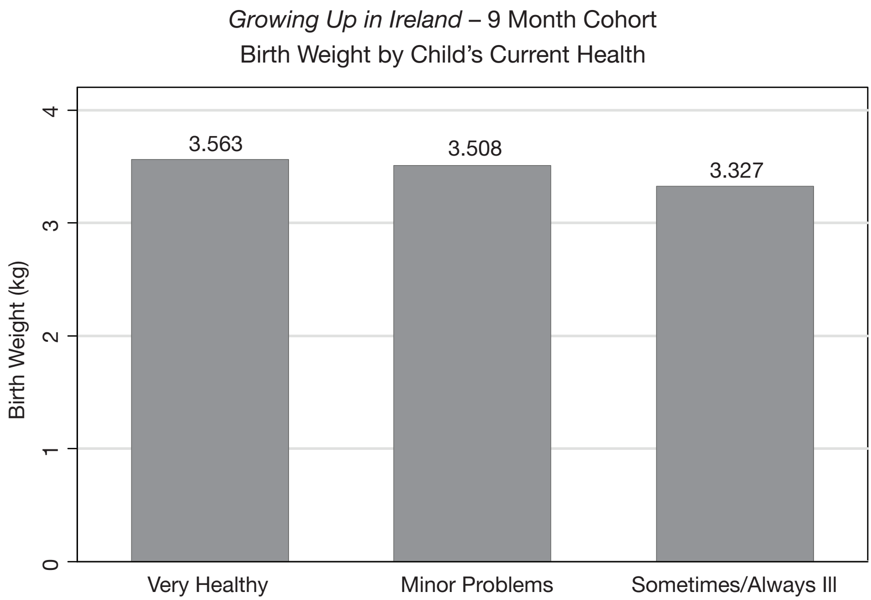
variables which retain a statistically significant effect on birth weight include the number of siblings in the household, household type, smoking in the household during pregnancy, the mother being in poor health, mother's smoking behaviour, maternal employment, weight gain during pregnancy, the timing of the birth, and the absence of pregnancy complications. These are summarised in Table 2. For example, smoking in the household during pregnancy reduces the baby's weight by nearly 30g, while having a mother who never smokes increases the baby's weight by 180g, compared to a mother who smokes regularly. It is important to reiterate that this model does not address the endogeneity of inputs into infant health, and therefore interpreting these results as causal is problematic, although again they are consistent with the previous findings discussed in Section II.

IV CONSEQUENCES OF BIRTH WEIGHT

Next, I turn to examine outcomes at age 9 using the second *GUI* cohort. The main issue of interest is the effect of birth weight, which is again reported by the main caregiver. I impose the same restrictions on the data as I did for the analysis of the 9 month cohort, namely I focus on the sample of children born in Ireland, whose mother was identified as the primary caregiver, and I also exclude non-singleton births. This reduces the sample from 8,568 to 7,282. The mean in the data is 3,546g which is similar to that in the 9 month data (and again consistent with official statistics). A lower percentage (compared with the 9 month data) is reported as having been of low birth weight (less than 2,500g), at 3.05 per cent. As with the previous cohort, this variable has also been censored at 1.7kg and 4.9kg.

I focus on four main outcomes, test scores on the official Drumcondra reading and maths achievement exams (for further information see www.erc.ie/index.php?p=33), the child's health as assessed by the mother, and whether the child had any stays in hospital. It is important to include this final measure, which is not subject to any reference bias that could be present in self-assessments. Likewise, although the data do contain information on assessments of performance in school by pupils, parents and teachers, the Drumcondra tests are immune to the doubts surrounding these subjective measures. For each of these outcomes, there is a strong bivariate association with birth weight. Figure 3 shows that those who are described, at age 9, as being sometimes/always ill had an average birth weight of 3,327g, compared to an average of 3,583g for those described as being very healthy. A similar relationship exists with whether the child has had any hospital stays, so this is not just an artefact of self-reporting.

Figure 3: *Birth Weight and Health (9 Year Cohort)*



N = 7,233, Mean = 3,547 kg.

It is important to allow for the fact that birth weight is likely to be correlated with any number of alternative family characteristics, including, but not limited to, those identified in the previous section. For example, maternal education is an important predictor of birth weight, but is also likely to be related to test scores. Table 3 presents estimates of the relationship between birth weight and some proxies for parental investments in their children. I use a simple regression where birth weight is the only independent variable. These results suggest that lower birth weight is associated with poorer neighbourhoods (as rated by either the parents or the children themselves), and poorer school quality. There is no relationship with a measure of the frequency of parent-child interaction, however, lower birth weight does predict higher levels of conflict and dependence on the main caregiver, as well as a higher degree of closeness (for further details on the Pianta scores used in the data see www.ucd.ie/issda/static/documentation/esri/GUI-Guide9YearCohort.pdf). While these are simple correlations, which tend to disappear when controls for other indicators of socio-economic status are added, and not intended to represent any causal relationship, they do highlight that low birth weight is associated with a number of other disadvantages. Not accounting for these factors could bias estimates of the effect of birth weight. Even if these measures of a child's environment do not fully explain the relationship between initial health and later outcomes, they may be at least compounding the effects of initial disadvantage. Almond and Currie (2010) discuss a framework for conceptualising investments which interact with initial conditions, and also some previous findings in the literature. Overall, the evidence is mixed. Datar *et al.* (2010) is one example of a study which finds some evidence that parents reinforce initial endowments, and invest less in children of low birth weight.

Table 3: *Birth Weight and Proxies for Parental Investments*

Variables	*OLS Neighbourhood*	*OLS Child's Neighbourhood*	*OLS School Quality*	*OLS Parenting Quality*
Birth Weight (kg)	0.4640***	0.1491**	0.5240**	0.0474
	(0.107)	(0.060)	(0.256)	(0.071)
Observations	7,200	6,529	5,567	7,227

Variables	*OLS Conflict*	*OLS Closeness*	*OLS Dependence*
Birth Weight (kg)	–0.5910**	–0.2185**	–0.2392***
	(0.252)	(0.106)	(0.093)
Observations	7,226	7,225	7,225

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Note: Regressions are weighted, unweighted results are similar. Birth weight is the only independent variable. The neighbourhood quality index is derived from the sum of a series of questions on safety in the locality, and is answered by the primary care giver. It ranges from 4 (problems are very common) to 28 (not at all common). The child's rating is derived from the sum of a series of questions answered by the child, such as whether they like living in their neighbourhood, and whether the streets are clean. It ranges from 0 (worst) to 15 (best). School quality is measured as the adequacy of school facilities summed across a number of domains, as ranked by the school principal. This index ranges from 17 (poor in all areas) to 68 (excellent in all areas). Parenting quality measures the amount of times per week the family engages in 5 types of activities together, ranging from 5 (all activities everyday) to 20 (never for any activity). Conflict, closeness and dependence with the primary caregiver are measured using Pianta scores.

Table 4 presents the results from a regression analysis, where I model the outcomes described above as a function of birth weight. In the first row, I start with a simple specification where I control for the gender of the child, the mother's age, and the mother's age squared. The first two columns are OLS regressions, where the Drumcondra maths and reading logit scores (these are standardised to have a mean of 0 in the population and a standard deviation of 1) are the dependent variables, while the third column are the marginal effects from a probit regression for whether the child experienced any stays in hospital. The final column is an ordered logit showing odds ratios for the mother's assessment of the child's current health. This variable ranges from 1 ("very healthy") to 3 ("sometimes/always unwell"). For test scores, I use a quadratic in birth weight. The squared coefficient is not significant for the other outcomes, therefore I conclude that the evidence in favour of non-linearity is restricted to maths and reading scores in these data. Each row presents the coefficient on the birth weight variable only, however the full table with all control variables is available in the online Appendix as Table 7. For the base specification, there is a significant relationship between birth weight and each outcome. As with the 9 month cohort, there are a number of variables with a relatively large proportion of missing values, therefore I again compare the results from using a missing value recode to using multiple imputation. As before, they are very similar.

In rows 2 and 3 of Table 4, I account for the possibility that individuals who experience lower birth weights may be more likely to live in areas with more social problems, or attend lower quality schools. I also control for parental behaviour. Each of these factors has the potential to distort the true relationship between birth weight and later outcomes, but fortunately the data provide a number of measures which proxy for school and area quality, along with parental investments. Adding these control variables has the effect of halving the coefficients for maths and reading scores, although the effect of birth weight remains significant, and the coefficients on hospital stays and health are relatively unaffected. Finally, I control for parents' height in row 4. For this final specification, a 1kg increase in birth weight is associated with a 4 percentage point reduction in the probability of a hospital stay. As coefficients from ordered models are difficult to interpret, I have also estimated the model for self-rated health by grouping this variable into two categories, and I examine the marginal effect of being in the top category. I find that a 1kg increase in birth weight increases the probability of being defined as "very healthy" by 4 percentage points. For test results, a 1kg increase in birth weight is associated with an increase in the maths score of approximately .6, and an increase in the reading score of approximately .4. These variables are standardised, so these effects refer to the child's position relative to those of the same age and grade. A 1kg increase translates into an additional .6 standard deviations on the maths test, therefore these are important effects. (This is ignoring the quadratic term. For the final specification the F value for the test of joint significance for birth weight in the maths equation is 6.21 ($P = .002$). The turning point for the marginal effect is

Table 4: *Birth Weight and Later Outcomes (Summary)*

Model Controls	*Coefficient*	*OLS* *Maths*	*OLS* *Reading*	*Probit MFX* *Any Hospital Stays*	*Ologit Odds Ratio* *Mother Assessed Health*
Basic	Birth Weight (kg)	0.8167***	0.6789***	–0.0490***	0.7477***
		(0.189)	(0.210)	(0.013)	(0.0476)
	Birth Weight Squared	–0.1024***	–0.0822***		
		(0.027)	(0.030)		
+ SES	Birth Weight (kg)	0.5994***	0.4262**	–0.0435***	0.7999***
		(0.174)	(0.193)	(0.014)	(0.052)
	Birth Weight Squared	–0.0791***	–0.0526*		
		(0.025)	(0.027)		
+ Behaviour/Parenting	Birth Weight (kg)	0.5369***	0.3468*	–0.0385***	0.7993***
		(0.173)	(0.191)	(0.014)	(0.053)
	Birth Weight Squared	–0.0708***	–0.0419		
		(0.025)	(0.027)		
+ Parental Height	Birth Weight (kg)	0.5897***	0.3864**	–0.0419***	0.8060***
		(0.173)	(0.191)	(0.014)	(0.054)
	Birth Weight Squared	–0.0810***	–0.0498*		
		(0.025)	(0.027)		

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Note: Regressions are weighted, unweighted results are similar. The coefficient presented shows the effect of birth weight on the outcome. The full table with all control variables is available in the online Appendix as Table 7. The basic model controls for child's gender, mother's age and mother's age squared. The socio-economic controls are the household's ability to make ends meet, rural area, household type, household social class, household income quintile, mother's education, father's education, area quality, area quality rated by child, school quality, and the proportion of parents who attend school meetings. Model 3 adds mother's health, mother smokes, mother drinks, family interaction with child, child's level of conflict, closeness and dependence with mother, mother's depression score, and parenting style, and parental height. The scale used for the mother's assessment of their child's health ranges from 1 ("very healthy") to 3 ("sometimes/always unwell").

approximately 3.75kg. For reading the F value for the test of joint significance for birth weight in the maths equation is 2.81 (P = .0605). The turning point for the marginal effect is approximately 3.9kg). These results are consistent with previous findings. I compare these coefficients to results from Jefferis *et al.* (2002), which is based on similar data from the UK 1958 *National Child Development Study*. I re-estimate the model above to match that used in their paper (no control variables, and a linear effect for birth weight). I find an effect of .15, which is very similar to that in the NCDS of between .17 and .19 (again in reference to Z scores).

These results are robust to alternative specifications, including when I consider low birth weight as an independent variable. I have also controlled for additional psychological variables, including, measures of the parents' marriage (Dyadic Adjustment Scale), the child's mental health (Piers-Harris self-concept scale), temperament (EAS scale), and behaviour (the Strengths and Difficulties questionnaire, answered by both the primary caregiver and the teacher). Ideally, variables which could represent the pathway through which the effects of birth weight are operating (such as poor behaviour in school) should not be controlled for, but in any case, adding these additional measures makes little difference to the results. I also consider adding further information on paternal characteristics, such as health, smoking, and employment status. As with the data from the 9 month cohort, this has little effect. I conclude that the effect of birth weight is robust to including a wide range of potential confounding factors, including socioe-conomic status, neighbourhood and school characteristics, maternal behaviour, and measures of parenting style and interaction with the study child.

There is some evidence in the literature that girls are more resilient to poor early life conditions than boys, for example infant mortality is generally higher among males (Drevenstedt *et al.*, 2008). When I split the sample by gender, estimates suggest that males are more adversely affected by low birth weight. These results are presented in Table 5 in the Appendix.

I also investigate heterogeneity by considering how the effect of birth weight varies across the test score distribution. Figures 4 and 5 show the OLS results compared with estimates from quantile regression, where I use the final specification from Table 4. The coefficients refer to the effect of birth weight at each conditional quantile (i.e. the test score conditional on the other covariates in the model). For maths, the effect of birth weight is largest before the median, and generally statistically different from zero. The coefficient is not distinguishable from the OLS estimate, apart from a range between the 20th and 40th deciles. For reading scores, there is some evidence of a decreasing effect across the distribution, however, as with maths, the estimate is not statistically different from the OLS coefficient The fact that individuals

Figure 4: *Quantile Regression: Reading Scores*

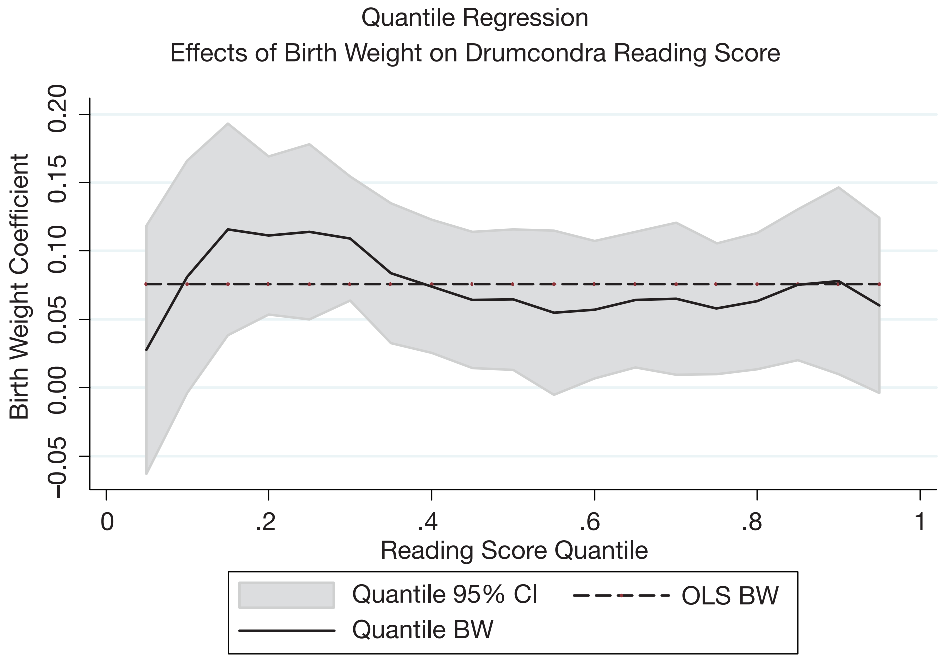
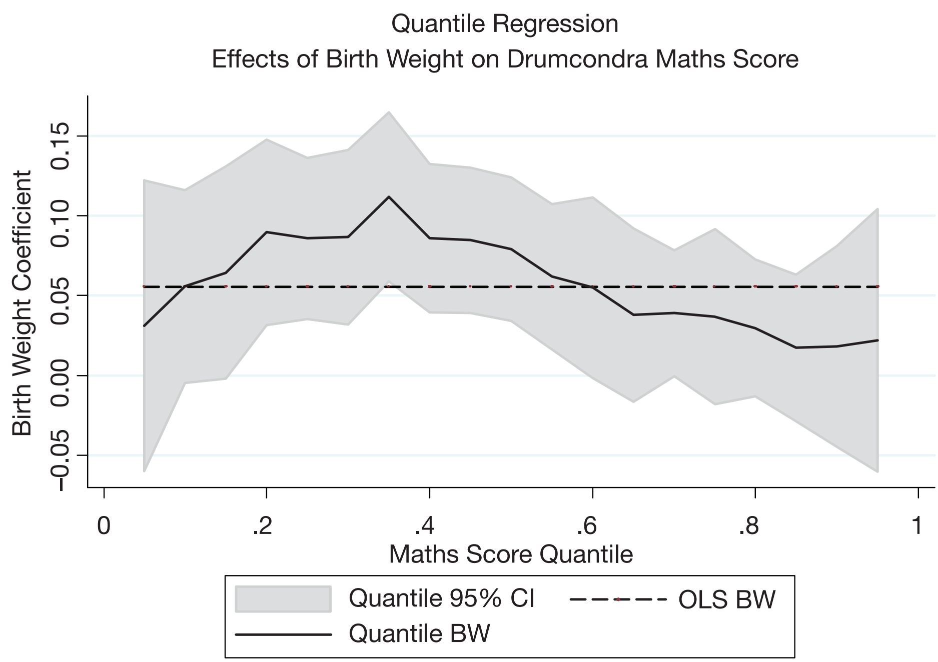


Figure 5: *Quantile Regression: Maths Scores*



most affected lie in the middle of the test score distribution suggests that those who are at the lower end of the (conditional) ability distribution were always likely to perform poorly, and are less affected by their birth weight. Likewise those at the upper end of the (conditional) ability distribution were always likely to perform well and are also less affected by their birth weight. A tentative conclusion from this analysis is that there is some heterogeneity in the effect of birth weight, in that those in the middle of the conditional ability distribution are most affected.

V CONCLUSIONS

This paper provides evidence on the determinants and effects of birth weight in Ireland. There is a strong social gradient in birth weight in the data, independent of how socioe-conomic status is measured, or whether birth weight is taken as continuous or there being a cut off at 2,500g. There are several important determinants of birth weight, including parental education and behaviour. However, the effects of maternal education are rendered statistically insignificant once a proxy for her early life conditions is added. Other important associations include household type; gender; smoking behaviour; absence of a mother's family; maternal health; maternal employment; weight gain during pregnancy; the timing of the birth and the absence of pregnancy complications. A body of evidence suggests that there are lasting causal effects of birth weight on later outcomes. I establish that birth weight predicts a number of measures at age 9, including test scores and health. These findings are independent of the effects of current socio-economic status and parental behaviour. Neither are they explained by measures of parental investments in their children, specifically, the quality of a child's neighbourhood and school, and psychological variables which measure parenting quality and style. The effects of birth weight are non-linear for test scores, and are larger for males. Using a quantile regression analysis, I establish that there is some evidence for a degree of heterogeneity in the effect of birth weight by ability. Accounting for missing values with multiple imputations has little impact on the results for either cohort.

There are important limitations to this study. The results presented here are associations, and there is the potential for some omitted variable to be biasing these estimates, therefore it is important to be cautious about drawing any conclusion with respect to causality. In particular, the role of genetics cannot be ruled out on the basis of the models used in this analysis. Nevertheless, I am able to control for a wide range of family background characteristics, many of which are typically not available in survey data. Taken in the context of the previous literature, particularly the results from siblings and twin studies, there is reason to believe that the effects presented here have a causal component. If this is the case, then this paper adds further weight to the view that there is scope for improving the outcomes of disadvantaged children by targeting initial health, particularly given the likelihood that low birth weight has some component which reflects intergenerational transmission. A summary of potentially effective public policies in this area is outlined in Almond and Currie (2010).

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APPENDIX

Table 5: *Birth Weight and Gender*

Variables	*OLS Maths*	*OLS Reading*	*Probit MFX Any Hospital Stays*	*Ologit Odds Ratio Mother Assessed Health*
	Male			
Birth Weight	0.7829***	0.3794	–0.0515***	0.7906**
	(0.236)	(0.256)	(0.019)	(0.075)
Birth Weight Squared	–0.1033***	–0.0477		
	(0.033)	(0.036)		
Observations	3,423	3,393	3,482	3,482
R-squared	0.187	0.197		
	Female			
Birth Weight	0.3764	0.2376	–0.0307	0.8068**
	(0.258)	(0.280)	(0.019)	(0.080)
Birth Weight Squared	–0.0581	–0.0299		
	(0.038)	(0.040)		
Observations	3,643	3,602	3,678	3,678
R-squared	0.177	0.227		

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Note: Regressions are weighted, unweighted test score results are larger for girls. The coefficient shows the effect of birth weight on each outcome for the final specification from Table 4.

ONLINE APPENDIX

Table 6: *Determinants of Birth Weight – Full Table*

Variables	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit (With MI)*
Mother's Age	26.1*	18.2	18.6	1.1	6.5	9.6
	(14.115)	(14.663)	(14.288)	(12.622)	(12.390)	(11.253)
Mother's Age Squared	–0.3	–0.3	–0.4	–0.0	–0.1	–0.2
	(0.233)	(0.240)	(0.234)	(0.207)	(0.203)	(0.184)
Mother Over 40	–38.4	–16.5	–19.0	–10.2	–5.0	–4.6
	(33.652)	(33.451)	(33.022)	(29.725)	(30.283)	(27.289)
Female	–123.5***	–130.8***	–131.5***	–134.2***	–124.2***	–117.2***
	(12.371)	(12.295)	(12.074)	(10.930)	(10.849)	(10.347)
HH Income: Missing	–0.6	13.4	7.9	1.2	3.2	
	(29.649)	(30.408)	(29.998)	(27.009)	(26.897)	
HH Income: 2nd Quintile	23.2	21.8	24.8	10.3	10.8	15.5
	(22.141)	(22.468)	(21.938)	(19.940)	(19.977)	(18.313)
HH Income: 3rd Quintile	39.2*	46.4**	41.4*	23.4	19.7	13.0
	(22.137)	(23.391)	(22.896)	(20.409)	(20.251)	(19.044)
HH Income: 4th Quintile	56.9**	92.7***	78.4***	70.0***	65.5***	57.3***
	(22.219)	(24.169)	(23.790)	(21.408)	(21.297)	(19.852)
HH Income: Highest Quintile	9.6	64.1**	44.6*	22.9	9.0	5.1
	(23.133)	(25.625)	(25.345)	(22.501)	(22.434)	(21.727)
Mother Age Left Education	9.2***	11.8***	7.8***	5.6**	0.6	1.1
	(2.606)	(2.683)	(2.667)	(2.412)	(2.429)	(2.252)
Father Age Left Education	6.0**	8.9***	7.4***	7.4***	7.5***	6.3***
	(2.521)	(2.598)	(2.578)	(2.353)	(2.347)	(2.064)
Father's Education Missing	73.8	161.0***	133.3**	129.4***	153.6**	
	(51.560)	(54.722)	(54.226)	(49.551)	(63.660)	
HH Social Class: Managerial and technical		–24.8	–21.8	–17.9	–17.5	–15.6
		(17.348)	(17.281)	(15.822)	(16.036)	(14.756)

Table 6: *Determinants of Birth Weight – Full Table (contd.)*

Variables	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit (With MI)*
HH Social Class: Non-manual		10.6	14.6	21.8	25.2	25.1
		(21.427)	(21.213)	(19.325)	(19.602)	(18.461)
HH Social Class: Skilled manual		–10.6	9.5	11.3	19.7	13.1
		(24.258)	(24.195)	(22.352)	(22.549)	(21.236)
HH Social Class: Semi-skilled		–39.9	–9.3	7.8	9.9	13.4
		(30.769)	(30.030)	(26.887)	(27.117)	(25.013)
HH Social Class: Unskilled		–80.2*	–52.0	–23.6	1.5	–9.2
		(48.653)	(46.638)	(44.396)	(43.779)	(39.260)
HH Social Class: Others occupied		–21.7	–64.6	–50.5	–26.8	–45.7
		(82.529)	(87.777)	(75.078)	(70.964)	(58.076)
HH Social Class: Never worked		–28.7	–1.4	10.6	13.4	17.4
		(38.308)	(37.403)	(34.105)	(33.828)	(31.871)
Number of Siblings in Household		31.0***	31.9***	23.0**	19.1**	19.9**
		(10.852)	(10.637)	(9.715)	(9.690)	(8.714)
HH Type: Parent 1 Child		–99.0**	–69.8	–83.5**	–106.1***	–62.2
		(43.364)	(42.561)	(37.924)	(38.148)	(42.191)
HH Type: Parent 2+Children		–88.6**	–55.4	–31.3	–51.6	–50.6*
		(40.541)	(38.561)	(36.011)	(35.907)	(29.331)
HH Type: 2 Parents 1 Child		–124.8***	–126.2***	–124.0***	–133.4***	–120.9***
		(20.491)	(20.133)	(18.142)	(18.114)	(16.568)
Rural Area		32.5**	29.7**	27.8**	24.1**	21.3**
		(12.823)	(12.668)	(11.381)	(11.288)	(10.282)
Mother Not Born in Ireland		3.1	17.4	1.0	3.2	–11.1
		(15.839)	(17.382)	(15.922)	(16.005)	(14.274)
Nhood Safety Problems		–7.4***	–5.5**	–3.3	–3.3	–2.8
		(2.474)	(2.409)	(2.177)	(2.138)	(1.999)
Someone in HH Smoked During			–36.8**	–36.7***	–28.9**	–25.4**
Pregnancy			(15.239)	(13.623)	(13.517)	(12.239)

Table 6: *Determinants of Birth Weight – Full Table (contd.)*

Variables	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit (With MI)*
Mother doesn't get enough help			21.2	35.4*	22.0	13.7
			(21.966)	(19.453)	(19.270)	(17.791)
Mother doesn't get any help at all			24.9	20.9	3.9	5.8
			(27.956)	(24.336)	(24.150)	(21.585)
Mother doesn't need any help			32.9	18.1	4.3	16.9
			(27.389)	(25.828)	(25.415)	(23.590)
Family not living in the country			–99.5***	–107.0***	–112.4***	–103.2***
			(28.981)	(25.965)	(25.961)	(23.100)
Don't Know about Help			104.2	91.1	29.9	–158.3
			(164.592)	(162.848)	(127.438)	(132.929)
Mother's health: Very good health			–2.3	–2.6	2.4	2.3
			(14.139)	(12.898)	(12.805)	(11.719)
Mother's health: Good			–13.9	–8.8	–2.7	1.2
			(17.069)	(15.571)	(15.523)	(14.094)
Mother's health: Fair			–73.7**	–44.3	–24.8	–9.2
			(30.997)	(26.965)	(26.358)	(24.299)
Mother's health: Poor			–99.5	–151.4**	–132.0*	–86.7
			(76.597)	(72.474)	(69.831)	(59.904)
Mother Smokes: Occasionally			137.4***	118.3***	126.7***	108.5***
			(26.545)	(24.023)	(23.723)	(21.795)
Mother Smokes: Not at all			183.7***	174.5***	180.8***	170.9***
			(19.889)	(17.664)	(17.437)	(15.947)
Mother Drinks: Less than once a month			22.3	11.0	4.4	–1.0
			(20.513)	(18.792)	(18.765)	(17.091)
Mother Drinks: 1-2 times a month			37.5*	28.1	6.3	4.7
			(20.424)	(18.749)	(18.625)	(17.147)
Mother Drinks: 1-2 times a week			32.4	21.6	3.0	–1.3
			(20.899)	(19.047)	(19.029)	(17.198)

Table 6: *Determinants of Birth Weight – Full Table (contd.)*

Variables	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit (With MI)*
Mother Drinks: 3-4 times a week			72.9**	34.3	12.9	3.4
			(33.330)	(29.651)	(29.270)	(27.140)
Mother Drinks: 5-6 times a week			–15.6	–49.3	–77.7	–97.7*
			(82.903)	(59.949)	(57.534)	(56.663)
Weeks before birth mother stopped				10.5***	9.5***	9.2***
working				(2.356)	(2.295)	(2.071)
Weeks before birth NA/Missing				54.3***	46.3**	49.5***
				(19.233)	(18.998)	(17.085)
Weeks become aware of pregnancy				0.7	0.4	0.2
				(2.668)	(2.664)	(2.335)
Weeks first ante-natal appointment				2.8*	2.7	2.3
				(1.625)	(1.654)	(1.468)
Weeks aware missing				–50.5	–26.5	
				(256.731)	(257.795)	
Weeks appointment Missing				–361.1**	–331.4**	
				(157.615)	(161.958)	
Gained weight during pregnancy (kg)				13.9***	12.2***	11.4***
				(1.057)	(1.041)	(0.921)
Missing weight gain				–1,207.9***	–1,054.8***	
				(92.358)	(91.052)	
Birth Timing: Very early				–1,299.3***	–1,272.7***	–821.3***
(32 weeks or less)				(84.333)	(82.856)	(31.538)
Birth Timing: Somewhat early				–722.6***	–719.9***	–608.4***
(33-36 weeks)				(33.178)	(32.691)	(24.540)
Birth Timing: Late birth				236.5***	228.5***	216.2***
(42 weeks or more)				(16.774)	(16.776)	(15.423)

Table 6: *Determinants of Birth Weight – Full Table (contd.)*

Variables	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit*	*Birth Weight Tobit (With MI)*
No Pregnancy Complications				57.3***	55.9***	48.3***
				(11.025)	(10.913)	(10.038)
Mother's Measured Height					14.8***	14.0***
					(0.912)	(0.839)
Father's Measured Height					5.8***	6.0***
					(0.917)	(0.991)
Missing Father's Height					1,008.2***	
					(168.522)	
Constant	2,788.7***	2,990.4***	2,950.8***	2,960.0***	–438.4	–352.8
	(210.165)	(227.095)	(224.158)	(200.373)	(279.827)	(282.355)
Observations	10,272	10,135	10,133	10,129	9,773	10,582

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Note: Regressions are weighted, unweighted results are similar. The omitted categories are as follows. For household income "1st Quintile", for household social class "professional", for household type "2 Parents 2+ Children", for help "mother gets enough help", for maternal health "excellent health", for maternal smoking "smoke daily", and for maternal drinking "never drink". The final column presents results where missing values are imputed from all the other variables in the model. 5 imputations are used, however results are also similar to when 50 imputations are employed. I use the chained equation approach detailed in Royston (2009).

Table 7: *Effects of Birth Weight – Full Table*

Variables	*OLS Maths*	*OLS Reading*	*Probit MFX Any Hospital Stays*	*Ologit Odds Ratio Self-Assessed Health*
Birth Weight (kg)	0.5897***	0.3864**	–0.0419***	0.8060***
	(0.173)	(0.191)	(0.014)	(0.054)
Birth Weight Squared	–0.0810***	–0.0498*		
	(0.025)	(0.027)		
Female	–0.0709***	0.0737***	–0.0713***	0.9507
	(0.026)	(0.028)	(0.015)	(0.068)
Mother's Age	0.0412	0.0409	0.0048	1.1133
	(0.028)	(0.031)	(0.017)	(0.090)
Mother's Age Squared	–0.0003	–0.0003	–0.0001	0.9986
	(0.000)	(0.000)	(0.000)	(0.001)
Number of Siblings in	–0.0275	–0.0998***	–0.0455***	0.8932**
Household	(0.020)	(0.020)	(0.012)	(0.051)
HH Make Ends Meet:	0.0244	0.3142***	0.0490	1.5890
With difficulty	(0.114)	(0.122)	(0.071)	(0.491)
HH Make Ends Meet:	0.1174	0.2675***	0.0259	1.3385
With some difficulty	(0.100)	(0.101)	(0.062)	(0.368)
HH Make Ends Meet:	0.1122	0.2386**	0.0224	1.1501
Fairly easily	(0.101)	(0.102)	(0.062)	(0.317)
HH Make Ends Meet:	0.1627	0.2173**	0.0464	1.2301
Easily	(0.103)	(0.104)	(0.064)	(0.344)
HH Make Ends Meet:	0.0869	0.1883*	0.0344	1.1694
Very easily	(0.107)	(0.110)	(0.066)	(0.345)
Rural	–0.0709***	–0.0758***	0.0148	1.0109
	(0.027)	(0.028)	(0.015)	(0.074)
Single Parent 1 or 2	–0.0409	0.0758	–0.0484	0.9687
children	(0.084)	(0.089)	(0.048)	(0.221)
Single Parent 3 or	–0.1318	–0.0400	–0.1289**	0.6891
more children	(0.097)	(0.100)	(0.051)	(0.181)
Couple 1 or 2 children	–0.0739*	–0.0568	–0.0249	1.0055
	(0.039)	(0.042)	(0.023)	(0.109)
HH Social Class:	–0.1100	–0.0805	0.1319***	1.4124
Missing	(0.086)	(0.091)	(0.049)	(0.309)
Managerial and	–0.0394	–0.0162	0.0232	0.8455
Technical	(0.045)	(0.044)	(0.025)	(0.105)
Non-manual	–0.0770	–0.0738	0.0104	0.8913
	(0.054)	(0.054)	(0.030)	(0.129)
Skilled manual	–0.1520***	–0.1593***	0.0402	0.8423
	(0.057)	(0.058)	(0.032)	(0.132)
Semi-skilled	–0.0950	0.0113	–0.0275	1.0071
	(0.065)	(0.065)	(0.037)	(0.182)
Unskilled	–0.0293	–0.0678	0.0817	0.8989
	(0.103)	(0.109)	(0.062)	(0.252)

Table 7: *Effects of Birth Weight – Full Table (contd.)*

Variables	*OLS Maths*	*OLS Reading*	*Probit MFX Any Hospital Stays*	*Ologit Odds Ratio Self-Assessed Health*
HH Income: Missing	0.0683	0.0701	0.0046	0.9047
	(0.060)	(0.062)	(0.036)	(0.149)
2nd Quntile	0.0865*	0.0885*	0.0167	1.1002
	(0.049)	(0.053)	(0.029)	(0.146)
3rd Quntile	0.0625	0.0703	–0.0009	1.0043
	(0.050)	(0.054)	(0.030)	(0.139)
4th Quntile	0.1393***	0.1445**	–0.0232	0.8064
	(0.051)	(0.057)	(0.030)	(0.117)
Highest Quntile	0.1247**	0.1050*	–0.0005	0.7243**
	(0.055)	(0.059)	(0.032)	(0.112)
Mother's Education:	0.1610**	0.2254***	0.0049	0.9868
Lower Sec	(0.072)	(0.077)	(0.041)	(0.179)
Mother's Education:	0.3547***	0.3385***	0.0134	0.8458
Hi Sec/TechVoc/ UppSec+Tech/Voc	(0.070)	(0.075)	(0.041)	(0.156)
Mother's Education:	0.3954***	0.4496***	0.0349	0.9108
Non Degree	(0.074)	(0.081)	(0.044)	(0.178)
Mother's Education:	0.5439***	0.6577***	0.0492	1.0112
Primary	(0.077)	(0.084)	(0.047)	(0.212)
Mother's Education:	0.4699***	0.6923***	0.0046	0.9861
Postgrad	(0.082)	(0.089)	(0.049)	(0.223)
Father's Education:	0.0945	0.1449	–0.0404	0.7229
Missing	(0.106)	(0.103)	(0.061)	(0.192)
Father's Education:	0.0045	0.1104	0.0202	0.7993
Lower Sec	(0.065)	(0.069)	(0.040)	(0.137)
Father's Education:	0.1935***	0.3366***	0.0345	0.7665
Hi Sec/TechVoc/ UppSec+Tech/Voc	(0.065)	(0.069)	(0.040)	(0.135)
Father's Education:	0.1284*	0.2807***	–0.0301	1.0146
Non Degree	(0.070)	(0.075)	(0.042)	(0.193)
Father's Education:	0.1928***	0.4151***	–0.0123	0.9842
Primary	(0.074)	(0.078)	(0.045)	(0.194)
Father's Education:	0.2694***	0.4632***	–0.0449	0.6902*
Postgrad	(0.077)	(0.082)	(0.046)	(0.145)
Area Index	0.0039	0.0029	–0.0015	0.9774**
	(0.004)	(0.004)	(0.002)	(0.010)
Child Area Index	0.0216***	0.0066	–0.0036	0.9751
	(0.007)	(0.007)	(0.004)	(0.018)
Child Area Index	0.2657***	0.0501	–0.0341	0.8371
Missing	(0.094)	(0.103)	(0.055)	(0.214)
School Quality Index	0.0006	–0.0008	–0.0001	1.0006
	(0.002)	(0.002)	(0.001)	(0.004)

Table 7: *Effects of Birth Weight – Full Table (contd.)*

Variables	*OLS Maths*	*OLS Reading*	*Probit MFX Any Hospital Stays*	*Ologit Odds Ratio Self-Assessed Health*
School Quality Index Missing	0.0651 (0.082)	–0.0574 (0.085)	0.0005 (0.046)	1.0871 (0.234)
Percentage Parents Attend School Meetings: Missing	0.1497*** (0.058)	0.2451*** (0.062)	0.0078 (0.034)	1.1632 (0.186)
Percentage Parents Attend School Meetings: 91–95%	0.0594* (0.036)	0.0830** (0.038)	0.0115 (0.021)	1.1729 (0.115)
Percentage Parents Attend School Meetings: 96–98%	0.0574 (0.042)	0.0255 (0.043)	0.0252 (0.024)	1.0222 (0.114)
Percentage Parents Attend School Meetings: 99 – 99%	0.0642 (0.039)	0.0762* (0.044)	–0.0038 (0.024)	1.1050 (0.125)
Percentage Parents Attend School Meetings: 100%	0.0917** (0.042)	0.1117*** (0.042)	0.0216 (0.024)	0.9751 (0.113)
Mother's Health: Very good	0.0208 (0.029)	0.0123 (0.031)	0.0103 (0.017)	1.4824*** (0.130)
Mother's Health: Good	–0.0151 (0.038)	–0.0712* (0.039)	0.0505** (0.021)	2.0262*** (0.206)
Mother's Health: Fair	–0.0601 (0.066)	–0.1500** (0.066)	0.0652* (0.037)	2.3267*** (0.354)
Mother's Health: Poor	0.0779 (0.169)	0.1602 (0.243)	0.1536* (0.083)	6.5647*** (2.144)
Mother Smokes: Occasionally	–0.0527 (0.056)	–0.0499 (0.059)	0.0118 (0.034)	1.0591 (0.161)
Mother Smokes: Not at all	0.0391 (0.035)	0.0847** (0.036)	–0.0194 (0.020)	1.0144 (0.094)
Mother Drinks: Less h than once a mont	0.1422*** (0.046)	0.0408 (0.048)	–0.0323 (0.027)	1.3742** (0.174)
Mother Drinks: 1-2 times a month	0.0153 (0.044)	–0.0443 (0.046)	–0.0277 (0.026)	1.0996 (0.137)
Mother Drinks: 1-2 times a week	0.0673 (0.041)	0.0714* (0.043)	–0.0566** (0.024)	1.1149 (0.128)
Mother Drinks: 3-4 times a week	0.1119** (0.054)	0.1460*** (0.056)	–0.0749** (0.030)	1.0884 (0.164)
Mother Drinks: 5-6 times a week	0.2015** (0.089)	0.1199 (0.118)	–0.0447 (0.061)	1.2215 (0.365)
Mother Drinks: Everyday	–0.0855 (0.143)	0.0990 (0.186)	–0.0838 (0.092)	0.9623 (0.404)
Family Interaction With Child Index	0.0084 (0.005)	0.0193*** (0.006)	–0.0045 (0.003)	1.0118 (0.015)

Table 7: *Effects of Birth Weight – Full Table (contd.)*

Variables	*OLS Maths*	*OLS Reading*	*Probit MFX Any Hospital Stays*	*Ologit Odds Ratio Self-Assessed Health*
Level of conflict with primary caregiver	–0.0079***	–0.0068***	0.0000	1.0147***
	(0.002)	(0.002)	(0.001)	(0.004)
Level of closeness with primary caregiver	–0.0007	0.0067*	0.0008	0.9840*
	(0.004)	(0.004)	(0.002)	(0.009)
Level of dependence with primary caregiver	–0.0120***	–0.0116***	0.0050**	1.0152
	(0.004)	(0.004)	(0.002)	(0.011)
Total depression score for primary caregiver	–0.0033	0.0022	0.0038	1.0137
	(0.004)	(0.004)	(0.002)	(0.011)
Depression Score Missing	–0.1132**	–0.1014*	0.0012	1.0222
	(0.051)	(0.054)	(0.029)	(0.137)
Parenting Style: Missing	–0.0431	–0.0077	–0.0351	1.0443
	(0.055)	(0.062)	(0.029)	(0.154)
Parenting Style: Authoritarian	–0.0164	0.0611	0.0828**	0.7921
	(0.071)	(0.076)	(0.042)	(0.153)
Parenting Style: Permissive	–0.0691*	–0.0989***	–0.0217	0.9518
	(0.036)	(0.036)	(0.020)	(0.097)
Parenting Style: Neglectful	–0.1838**	–0.2029**	0.0848	0.9533
	(0.092)	(0.099)	(0.059)	(0.264)
Primary caregivers measured height in cms	0.0088***	0.0068***	0.0025*	0.9969
	(0.002)	(0.002)	(0.001)	(0.006)
PCG Height Missing	1.4479***	1.0755***	0.3268*	0.6563
	(0.389)	(0.401)	(0.182)	(0.682)
Secondary caregivers measured height in cms	0.0038*	0.0041*	–0.0013	0.9951
	(0.002)	(0.002)	(0.001)	(0.006)
SCG Height Missing	0.6910*	0.7316*	–0.1678	0.4356
	(0.384)	(0.404)	(0.217)	(0.480)
Constant	–5.6667***	–4.8249***		
	(0.823)	(0.923)		
Observations	7,066	6,995	7,160	7,160
R-squared	0.171	0.200		

Robust standard errors in parentheses.
*** p<0.01, ** p<0.05, * p<0.1.
Note: Regressions are weighted, unweighted results are similar. The omitted categories are as follows. For making ends meet "with great difficulty", for household income "1st Quintile", for household social class "professional", for household type "2 Parents 2+ Children", for maternal and paternal education "none/primary", for attendance at school meetings "less than 90 per cent", for maternal health "excellent", for maternal smoking "smoke daily", for maternal drinking "never drink", and for parenting style "authoritative". Mother's assessment of their child's health ranges from 1 ("very healthy") to 3 ("sometimes/always unwell").