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Decomposing Socioeconomic Inequalities in Childhood Obesity: Evidence from Ireland

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ABSTRACT

The objective of this paper is to quantify and decompose the socioeconomic gradient in childhood obesity in the Republic of Ireland. The analysis is performed using data from the first wave of the Growing Up in Ireland survey, a nationally representative survey of 8,568 nine year old children conducted in 2007 and 2008. We estimate concentration indices to quantify the extent of the socioeconomic gradient in childhood obesity and undertake a subsequent decomposition analysis to pinpoint the key factors underpinning the observed inequalities. Overall the results confirm a strong socioeconomic gradient in childhood obesity in the Republic of Ireland. Concentration indices of obesity (CI=-0.168) and overweight/obese (CI=-0.057) show that the gradient is more pronounced in obese children, while results from the decomposition analysis suggest that the majority of the inequality in childhood obesity is explained by parental level variables. Our findings suggest that addressing childhood obesity inequalities require coordinated policy responses at both the child and parental level.

KEY WORDS

Childhood obesity; socioeconomic inequality; concentration index; decomposition; Ireland.

1. INTRODUCTION

Obesity is a significant and growing public health problem in many countries. In the Republic of Ireland, approximately 18% of adults are now obese (National Taskforce on Obesity, 2005), with recent evidence suggesting that prevalence rates are increasing (Madden 2013). This has significant consequences for both the individual, in terms of morbidity (Renehan et al., 2008) and reduced quality of life (Jia and Lubetkin, 2005; Forste and Moore, 2012), as well as for society in terms of higher healthcare expenditures and lost output (Wang et al., 2011; Cawley and Mayerhoefer, 2011). Obesity is seen as a key contributor to a number of diseases with, for example, 44% of the diabetes burden, 23% of the ischemic heart disease burden and between 7% and 41% of the burden of certain cancers being attributed to overweight and obesity (Renehan et al., 2008; Van Baal et al., 2008). Of further concern is the fact that childhood obesity has also grown rapidly in recent years, thereby escalating the burden of both immediate and long-term health effects. For example, while most of the costs associated with obesity among children will be incurred in the future, research in the United States (US) has shown that obesity related problems amongst children cost the health service as much as $14.1 billion annually (Trasande and Chatterjee, 2009). Recent studies in Ireland have suggested that overweight and obese patients have €24 million higher primary care costs than those of normal weight patients, with potential economic costs of obesity being as high as €1.13 billion annually (Doherty et al., 2012; Perry, 2012). In this context, there has been an increased focus by policymakers on targeting childhood obesity, with a view to reducing both the current and future costs associated with obesity.

A number of studies in the US and Europe have identified significant childhood obesity rates, and while obesity rates in the US exceed those in Europe, there is considerable variation across European countries. For example, a clear division between southern (Mediterranean) and northern countries has emerged. Studies have shown that Portugal, Spain, Malta, Greece and Italy have the highest obesity rates among 7-9 year olds in Europe at approximately 10%, with rates twice as high as seen in the Netherlands, Denmark, Germany and Sweden (Lobstein et al., 2005; Valdés Pizarro and Royo-Bordonada, 2012; Chrzanowska et al., 2007)[1]. In comparison, obesity rates in Ireland and the United Kingdom are estimated to lie between these two groups (Whelton et al. 2007). In addition to identifying prevalence rates, studies in Europe (Stamatakis et al., 2010) and the United States (Singh et al., 2008) have also identified a significant socioeconomic gradient in childhood obesity rates i.e. the incidence of obesity increases as socioeconomic status falls. Indeed, the evidence suggests that while obesity rates may be levelling off in some cases, a more pronounced socioeconomic gradient is emerging across many European countries (Knai et al., 2012), though there may well be some heterogeneity in these observed inequalities (Bammann et al., 2012).

In order to formulate targeted and effective policies to reduce the prevalence of childhood obesity, policymakers must first fully understand the extent of the problem, as well as its determinants. In Ireland, two studies to date have focussed on the prevalence of childhood obesity and the factors associated with it. Whelton et al. (2007) found that approximately 6% of children in the Republic of Ireland and Northern Ireland were obese, and that the prevalence of obesity increased as children aged. Furthermore, the overall prevalence of overweight and obesity was found to be higher among girls than boys in both jurisdictions. However, no socioeconomic gradient was found by Whelton et al. (2007) for the Republic of Ireland, using free access to primary health care (access to which is primarily based upon low income) as a proxy for socioeconomic status.

[1] The obesity rates referenced here are based on the International Obesity Taskforce (IOTF) methodology.

In a more recent and comprehensive study, Layte and McCrory (2011) found that 19% of 9 year old children in Ireland were overweight, while 7% were obese, with prevalence rates of the latter greater amongst girls than boys (8% versus 5%). A range of obesity risk factors were examined, including levels of dietary quality, physical activity and sedentary behaviours, as well as the influence of the local food environment and socioeconomic factors. In contrast to Whelton et al. (2007), the study found "pronounced social-class inequalities in the prevalence of overweight and obesity" with significantly higher proportions of both boys and girls from semi-skilled and unskilled social-class households being classified as either overweight or obese, when compared to boys and girls from professional households. Given this, they conclude that the "health behaviours (unhealthier diets and less physical exercise) and higher levels of obesity among working-class children suggest that resources for interventions should be heavily targeted at lower socio-economic schools and communities."

Thus, effective policies to target overweight and obesity should be informed by an assessment of the factors driving socioeconomic gradients. In this context, the concentration index is now one of the most important methods used to quantify socioeconomic inequalities in health service utilisation and health issues such as obesity amongst adults (Madden, 2013) and childhood obesity (Zhang and Wang, 2007). It shows how a health outcome, such as obesity, varies according to some measure of socioeconomic status, such as income, providing a single measure of any income related inequality. Madden (2013) has utilised this method when analysing the social gradient in obesity in Irish adults, but to date it has not been used to examine obesity in Irish children. Concentration indices can also be decomposed into separate contributions where the impact of individual level regressors (e.g. social class or parental BMI) can be computed.

While Layte and McCrory (2011) clearly demonstrate a pronounced socioeconomic gradient in childhood overweight and obesity in Ireland, the study did not quantify the extent of this inequality using a concentration index, nor did it seek to decompose the factors which might be driving the gradient. In fact, while a number of previous studies have decomposed the determinants of the socioeconomic gradient in adult obesity, very few have done likewise in the context of childhood obesity, while none have done so for Ireland. This paper fills this gap using the same dataset as utilised by Layte and McCrory (2011). It estimates concentration indices to quantify the extent of the social gradient in childhood obesity in Ireland and undertakes a decomposition analysis to pinpoint the factors that drive the observed inequalities. To the best of our knowledge, this is the first paper to utilise the decomposition technique to quantify the main determinants of childhood obesity in a developed country. The findings have implications for the formulation of policies which seek to reduce the prevalence of, and socioeconomic inequalities in, overweight and obesity in Ireland and other countries.

The paper proceeds as follows: the next section sets out our materials and methods, including an overview of the dataset and a discussion of the concentration index of obesity and decomposition analysis techniques that are employed. The subsequent section sets out the key results and findings from the analysis, while the final section presents our discussion and concluding remarks.

2. MATERIALS AND METHODS

2.1 Data

The data analysed is from the first wave of the Growing Up in Ireland (GUI) survey conducted in 2007 and early 2008. This is a nationally representative survey of 8,568 children that examines issues concerning children, their care givers, teachers and school principals. The main aim of the GUI survey is to allow, for the first time, a clear, in-depth assessment of children in Ireland and their development in the current social, economic and cultural environment, with a view to assisting in policy formation and service provision for children. It includes approximately 14% of all nine year olds in the Republic of Ireland in 2008, with a two-stage clustered randomised sampling approach of 910 randomly selected schools being used to generate the sample. In total, 50.8% of children within these schools were included within the study, based upon parental consent. Further details of the survey, including the sampling procedures, are discussed extensively in Murray et al. (2009).

The GUI survey includes a wide range of variables of relevance for the analysis in this paper, both in terms of defining overweight and obesity, and in distinguishing the factors driving their socioeconomic gradients. Of particular importance is body mass index (BMI), calculated by dividing independently recorded weight in kilograms by height in metres squared. A major advantage of the GUI data is that weight and height were measured by those conducting the survey, thereby allowing more precise measurements of BMI[2]. While a BMI greater than 30 is commonly used to classify obesity in adults (though there is some debate in relation to the appropriateness of this), there is less agreement as to the appropriate

[2] According to Murray et al. (2009), "a Leicester portable height measure was used to record height. The Leicester measure gives height in imperial and metric units, but the interviewer recorded height to the nearest millimetre. It has a range of 0–2.07m. A SECA 761 flat mechanical scales was used for recording weight. They are a Class IIII, medically approved scales. The scales give weight on the metric scale only and have a capacity of 150kg with 1kg graduations. Interviewers recorded weight to the nearest kilogram. Height and weight readings were recorded on the interviewer's Work Assignment Sheet for each household".

cut-offs that should apply for children. For the purposes of the analysis in this paper, we classify 'obesity' on the basis of the IOTF cut-offs for boys and girls aged 9 years and 6 months, with a second set of cut-offs for those who are either overweight or obese (subsequently labelled 'overweight/obese'). This implies that the 'obesity' and 'overweight/obese' cut-offs represent distinct points on the right tails of the BMI distributions – see Cole et al. (2000) and Cole et al. (2007).

These IOTF cut-offs were chosen because of their wide application in recent literature. In international studies other methods have also been used, but give much higher childhood obesity rates compared to the IOTF method (Twells and Newhook, 2011). The higher specificity of the IOTF cut-offs may be important in identifying the most worrisome obese children, as Reilly and Wilson (2006) have stated that using a higher (stricter) cut-off for obesity may help to differentiate between children's obesity that is related to body fat rather than being more muscular. Furthermore, the top and bottom 0.5% of the sample's BMI and income distributions were trimmed from the analysis, in order to control for outliers that might bias the results[3], while some observations were dropped due to missing data. Overall, this gives a sample of 6,926 children. Since this includes children with at least one parent in the household, we also conducted our analysis on children with 2 parents present in the household, in order to reduce heterogeneity between families. This gives a second smaller sample of 5,869 for analysis.

Descriptive sample statistics for the variables considered are reported in Table 1, with a more comprehensive definition of the variables presented in the Appendix. These variables include equivalised net household income, which is used as the ranking variable in the construction

[3] This approach was also followed by Madden (2013). Results were very similar when outliers were included and are available on request.

of the concentration curves and indices. Participants in the GUI survey were asked to estimate their self reported household income value after deductions for tax, in terms of a weekly, monthly or yearly estimate. Based on this estimate, the GUI dataset provides a yearly household income value and an equivalised household income variable which we utilise. While a number of equivalence scales could have been used (e.g. OECD equivalence scale, square root of number in household, etc.), the equivalence scale provided in the GUI dataset was the one chosen here. This scale takes a value of 1 for the first adult in the household, 0.66 for any subsequent adults and 0.33 for each child.

[Insert Table 1 about here]

The variables used in the decomposition include a range of explanatory variables which are thought to influence BMI and, more importantly, the social gradient in obesity rates in children. These include a range of socioeconomic variables, household variables, parental age variables, parental health and behaviour variables[4], as well as a set of variables relating to the child. These variables were included on the basis of overweight and obesity risk factors for children identified in previous research, as well as the data available in the GUI survey. The analysis was conducted both with and without sample weights, though the final results presented in this paper are from the unweighted sample[5]. Furthermore, while it may have been preferable to cluster the sample by school, this was not possible due to confidentiality concerns associated with the dataset. In particular, it was stated that "since the original ID codes for each household were based on Area and Household codes (Area equating to school in this case) [it was] decided, for anonymisation purposes, to create new IDs for each

[4] For mothers, smoking status and alcohol consumption during pregnancy were chosen instead of current smoking status and alcohol consumption, in order to test the impact of mothers' health behaviour during pregnancy. Results are similar if current variables are included instead.

[5] Results are similar in both cases and available from the authors on request.

household. This removes the possibility of schools, especially smaller ones, being readily identified" (Growing Up in Ireland, 2009). Thus, we could not control for geographic location in the analysis beyond including an urban/rural indicator variable.

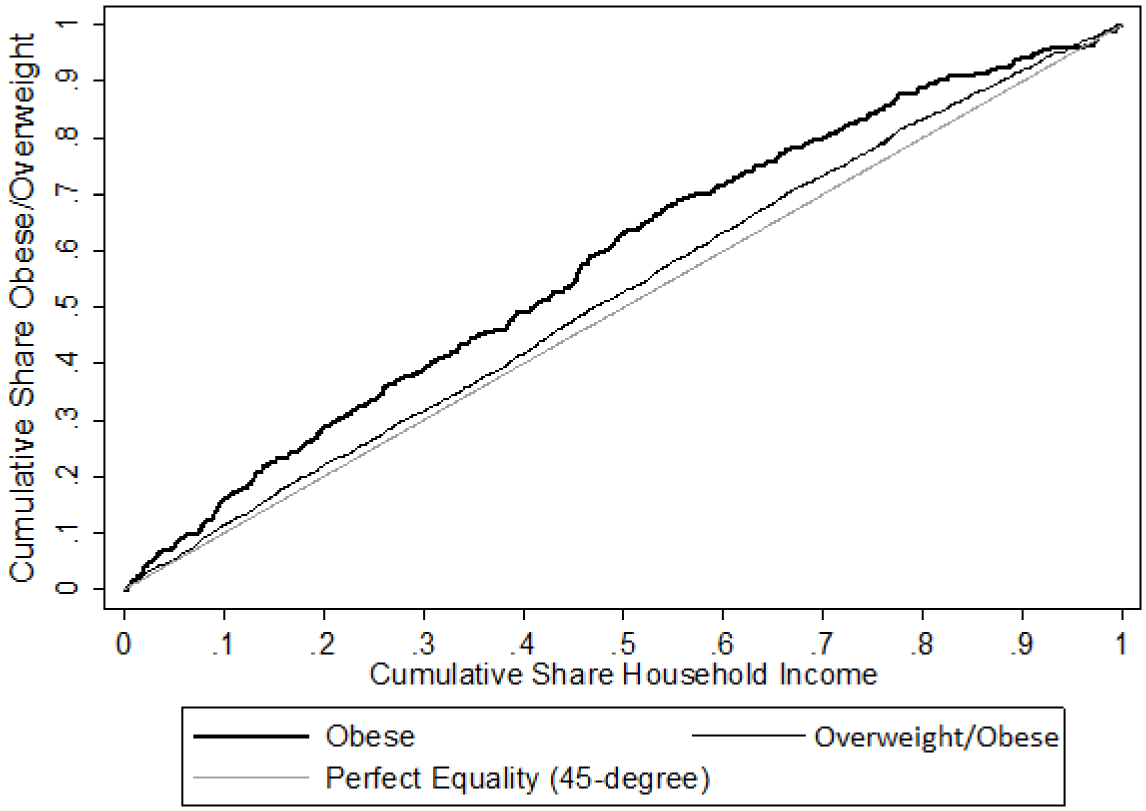
2.2 Concentration Index

Concentration indices are commonly used as a means of quantifying socioeconomic inequalities and are derived from the more well known Gini coefficient. While the Gini coefficient generally measures income inequality across the income distribution, the concentration index generally measures inequality in the distribution of a health variable (e.g. obesity) across the income distribution. As a result, the concentration index uses two variables, a dependent variable (y, obesity) and a ranking variable (R, income), while the Gini coefficient only uses one, income, as both the dependent and ranking variable.

Thus, in calculating a concentration index, the ranking variable ranks individuals based upon their income (which we have equivalised), with the poorest (lowest income) at the bottom of the ranking distribution and the richest (highest income) at the top of the ranking distribution. In other words, all individuals enter the distribution depending upon their income relative to the others in the ranking distribution. The index then computes an inequality based upon the proportion of the dependent variable (e.g. whether the child is obese or not) along each part of the ranking distribution. If the greatest proportion of obesity is evidenced among the poorest, a negative value (<0) is computed, while if the greatest proportion of obesity is evidenced among the richest, a positive value is computed (>0). The concentration index is bounded between -1 (perfect pro-poor inequality) and +1 (perfect pro-rich inequality) and perfect equality occurs where obesity is distributed equally across the income distribution, giving a concentration index of 0.

Concentration indices can be represented graphically using concentration curves, which depict differences in the proportional share of, for example, obesity across socioeconomic groups. For example, Figure 1 presents concentration curves for both children who are obese and for children who are either overweight or obese (overweight/obese) based on the GUI data. In particular, it shows the relationship between the cumulative share of household income on the horizontal axis and the cumulative share of obesity or overweight/obese on the vertical axis. The 45^{o} line represents the line of perfect equality (equivalent to a concentration index equal to zero), such that concentration curves lying above this line indicate 'pro-poor' inequality e.g. obesity among children is more prevalent amongst poorer households. It is noticeable from Figure 1 that the socioeconomic gradient traced by the concentration curve for obesity is higher than for the overweight/obese curve, suggesting that the socioeconomic inequalities are more pronounced for obesity than for overweight/obese.

Figure 1: Concentration curves of childhood obesity and overweight/obese



Source: Analysis of GUI data.[6]

As stated, equivalised household income is used as the ranking variable in the construction of the concentration curves and indices. The use of a continuous equivalised income variable implies that individuals have unique income values, providing more accurate comparisons than given by categorical variables, where values may be repetitive across many individuals (Chen and Roy, 2009). In our final sample there are however some ties and overall we have 2,073 unique income values for the 6,926 observations, reducing considerably any bias that may be caused by grouping or repetitive values.

Following previous studies (Kakwani et al., 1997; Van Doorslaer et al., 1997), the

[6] The 'overweight/obese' BMI category combines the 'obese' and 'overweight BMI categories

concentration index (CI) can be calculated as:

$$CI = \frac{2}{N\bar{y}}\sum_{i=1}^{N} y_i R_i - 1 \qquad [1]$$

where y_i denotes the dependent variable of interest (e.g. obesity), $\bar{y}$ represents its mean and R_i denotes the fractional rank of each individual along the equivalised income distribution. Here $i = 1$ for the individual at the bottom of the income distribution (the poorest in the sample) and $i = N$ for the individual at the top of the distribution (the richest in the sample).

As the dependent variables in this paper are binary responses (e.g. whether children were obese or not), a normalisation is required so that the concentration index is quantified in the range -1 to 1. Two different approaches are available to for this, namely by Wagstaff and Erreygers. There has been much discussion and debate regarding the appropriate normalisation to be followed when using binary variables – see, for example, Erreygers and Van Ourti (2011). We use the Wagstaff normalisation since the rate of obesity in our sample is only 5% and it tends to work better for low frequency binary outcomes, as well as its emphasis on relative inequality[7]. The normalisation can be represented as:

$$CI_n = \frac{CI}{1 - \bar{y}} \qquad [2]$$

2.3 Decomposition Analysis

The concentration index uses one socioeconomic variable, equivalised income, to compute inequality and this inequality can be decomposed to estimate the impact of other variables, such as education and social class, in determining the inequality. Thus, the decomposition

[7] Kjellsson and Gerdtham (2013) discuss the differences between inequality indices in detail and state that the decision to use Wagstaff's rather than Erreygers' normalisation is a choice between relative and absolute inequalities and the index the researcher chooses should be based on their own judgement.

allows for other variables that contribute to inequality to be included within the analysis and permits a clearer quantification of the impact of the variables underpinning any observed inequality (Van Doorslaer and Koolman, 2004)[8]. Following the decomposition, a variable will be found to have no impact on inequality if the variable has no significant impact on the dependent variable and/or is evenly distributed across the income distribution.

Since we use a binary variable as the dependent variable in our models, we compute average partial effects[9] (see Van Doorslaer et al. (2004) for a previous application) following a generalized linear model (GLM) with binomial family and probit link. The use of the GLM instead of an ordinary Probit regression has the added benefit of consistency of results for groups of dummy variables, regardless of the base category that is chosen (Yiengprugsawan et al., 2010). For example, results relating to socioeconomic class will be consistent regardless of whether the highest or lowest social class is chosen as the base category in the analysis. Equation [3] presents the decomposition of the concentration index. While van Doorslaer et al. (2004) use a standard concentration index in their decomposition, we follow Walsh et al. (2012) in decomposing our normalised index (CI_n), which reflects the binary nature of our dependent variables.

$$CI_n = \left(\frac{\beta_r \bar{x}_r}{\bar{y}}\right) CI_r + \sum_k \left(\frac{\beta_k \bar{x}_k}{\bar{y}}\right) CI_k + \frac{GC_\varepsilon}{\bar{y}} \qquad [3]$$

Our income variable is included in its logarithmic form as CI_r will equal the overall inequality if income is included in its linear form in the decomposition (Van Doorslaer et al.,

[8] For example, while a concentration index may highlight a pro-rich inequality in health care utilization, a decomposition can help to determine whether it is health insurance rather than income that is responsible for the inequality in utilisation.
[9] This was calculated in STATA 11.0 using the Margeff command – see Bartus (2005) for a discussion.

2004)[10]. Thus, the contribution of logarithmic income (denoted r) to the inequality, controlling for the other socioeconomic variables, is observed by the first expression on the right hand side of Equation [3]. Specifically, β_r represents the average partial effect from our GLM regression for logged income, $\bar{x}_r$ is the mean of logarithmic income and CI_r is the concentration index for logarithmic income in the decomposition. The second expression on the right hand side of Equation [3] represents the contributions of the other k variables included in the model, with β_k the average partial effect, $\bar{x}_k$ the mean and CI_k the concentration index for each individual regressor.

The contribution of each variable to the overall inequality (CI_n) is calculated by $\left(\frac{\beta_k \bar{x}_k}{\bar{y}}\right) CI_k$ and the percentage contribution estimated by dividing this term by our original concentration index (CI_n). The addition of the contributions of all the determinants in the model is the 'predicted' concentration index i.e. the quantity of the inequality that is explained by the determinants. The 'unpredicted' or residual component of the index is given by the final expression in Equation [3]. This final part, the residual term, is the part of the decomposition unexplained by the regressors contribution within the regression, but also takes into account the distribution of the residual across the Ranking variable (Jones and Lopez-Nicholas, 2006).[11]

3. RESULTS

Table 1 presents sample descriptive statistics, distinguishing between children who are categorised as obese, overweight, overweight/obese, recommended weight and underweight.

[10] We also tested the inclusion of a set of income dummy variables.

[11] The residual term can be expressed as $GC_\varepsilon = \frac{2}{n}\sum_{i=1}^{N} \varepsilon_i R_i$ with ε_i representing the residual term in the regression and $\sum_{i=1}^{N} \varepsilon_i R_i$ representing the distribution of the error term across the ranking variable. In this sense it is very similar to a concentration index used to help calculate the contributions of the regressors.

Overall 5.34% of the trimmed sample are classified as obese using the IOTF cut-offs and the table shows there is a strong association between childhood obesity rates and income, socioeconomic group and parental education. Overall, these results are indicative of a large socioeconomic gradient in childhood obesity in Ireland. A similar pattern is observed with respect to overweight for socioeconomic group and parental education, though is not as pronounced, while there is also evidence of a gradient for the combined 'overweight/obese' group. Parental BMI also has a significant association with both obesity and overweight rates in children, while diet and sedentary activities are also shown to have some association. While not the main focus of this paper, it is notable that over 7% of children in the subsample are classified as underweight, though little socioeconomic variation in its prevalence is evident, except when mother's education is considered. Birth weight, on the other hand, has a strong association with the prevalence of underweight in nine-year-olds. However, since the focus in this paper is on obese and overweight children, we do not consider the recommended weight and underweight categories in the subsequent discussion.

Table 1: Sample descriptive statistics by BMI category (%)

	Obese	Overweight	Overweight/ Obese	Recommend ed	Underweight
Sample Size (n)	**370**	**1,303**	**1,673**	**4,760**	**493**
Sample Size (%)	**5.34**	**18.81**	**24.15**	**68.73**	**7.12**
Equivalised Net Household Income*					
1st quintile	7.43	18.83	26.26	66.88	6.85
2nd quintile	5.34	18.30	23.65	68.23	8.12
3rd quintile	6.08	19.91	26.00	67.20	6.81
4th quintile	4.92	19.61	24.54	69.91	6.28
5th quintile	2.92	17.40	20.32	72.15	7.53
Socioeconomic Variables					
Socioeconomic Group					
SEG1	1.99	15.11	17.10	74.40	8.50
SEG2	4.39	18.34	22.73	70.41	6.86
SEG3	6.31	19.45	25.76	66.84	7.40
SEG4	7.30	20.49	27.79	65.45	6.76
SEG5	8.25	21.45	29.70	63.92	6.38
Mother's Education					
Mother/P1: Degree or above	2.67	16.55	19.21	73.01	7.77
Mother/P1: Upper secondary	5.60	18.96	24.56	68.10	7.34
Mother/P1: Lower secondary or below	8.60	21.84	30.44	64.23	5.33
Father's Education					
Father/P2: Degree or above	2.14	14.62	16.76	75.17	8.07
Father/P2: Upper secondary	5.30	19.25	24.55	68.09	7.36
Father/P2: Lower secondary or below	7.39	20.76	28.15	65.16	6.69
Household Variables					
Household Location					
Urban	5.10	18.63	23.73	68.93	7.33
Rural	5.55	18.97	24.51	68.55	6.94
Own Home					
Yes	5.01	18.37	23.38	69.51	7.10
No	7.11	21.15	28.26	64.54	7.20
Grocery Shops					
Yes	5.30	18.90	24.19	68.64	7.16
No	6.01	17.59	23.61	69.93	6.46
Recreational Facilities					
Yes	4.63	18.53	23.16	69.54	7.30
No	6.39	19.23	25.62	67.53	6.85
Parental Age*					
Mother's Age					
Mother/P1: Age 40 or over	4.78	17.93	22.71	69.94	7.35
Mother/P1: Age 39 or below	6.02	19.86	25.88	67.28	6.84
Father*'s Age*					
Father/P2: Age 40 or over	4.75	17.96	22.71	69.75	7.54
Father/P2: Age 39 or below	5.61	19.47	25.09	67.96	6.96
Parental Health and Behaviour Variables					
Mother's BMI*					

Mother/P1: BMI<=24.99	2.14	13.83	15.97	74.48	9.55
Mother/P1: BMI 25-29.99	6.65	20.93	27.59	66.77	5.64
Mother/P1: BMI 30 and above	11.74	28.62	40.35	56.51	3.14
Father's BMI*					
Father/P2: BMI<=24.99	2.46	12.85	15.31	73.08	11.62
Father/P2: BMI 25-29.99	4.20	17.30	21.50	70.98	7.53
Father/P2: BMI 30 and over	8.78	25.34	34.12	62.41	3.47
Mother's Smoking Status					
Mother/P1: Smoked during pregnancy	7.70	23.54	31.24	63.23	6.53
Mother/P1: Didn't smoke	4.67	17.45	22.12	70.59	7.29
Father's Smoking Status					
Father/P2: Current smoker	6.85	20.56	27.41	66.07	6.52
Father/P2: Non smoker	4.37	17.64	22.01	70.33	7.66
Mother's Alcohol Use#					
Mother/P1: Drank during pregnancy	4.71	17.46	22.17	70.77	7.06
Mother/P1: Weekly or more	5.75	19.69	25.44	67.40	7.16
Father's Alcohol Use#					
Father/P2: Never	6.69	19.89	26.58	64.74	8.68
Father/P2: Once month or less	6.12	19.13	25.25	67.35	7.41
Father/P2: Weekly or more	4.19	17.83	22.02	70.83	7.15
Child Variables					
Gender					
Male	4.53	16.90	21.43	72.61	5.96
Female	6.10	20.61	26.72	65.08	8.20
Breastfed					
Yes	4.02	17.38	21.40	71.18	7.42
No	6.76	20.35	27.11	66.10	6.79
Child Health					
Very healthy	4.69	18.55	23.24	70.05	6.71
Healthy	7.27	19.48	26.74	64.98	8.28
Sometimes unhealthy	6.52	21.74	28.26	63.04	8.70
Doctor Visits Last Year#					
None	5.18	18.44	23.62	69.35	7.03
One	4.37	18.68	23.05	70.13	6.82
Two or more	6.84	20.03	26.87	65.43	7.70
Nights in Hospital#					
None	4.81	18.28	23.09	69.98	6.93
One	4.40	17.45	21.85	69.35	8.80
Two or more	6.54	20.16	26.70	66.36	6.94
TV Hours#					
One hour or less per day	3.11	16.15	19.26	71.75	8.99
More than one hour per day	6.13	19.75	25.88	67.66	6.46
TV in Bedroom					
Yes	7.29	17.12	28.96	64.29	6.75
No	4.19	21.68	21.30	71.36	7.34
Reading Hours#					
One hour or less per day	4.99	18.67	23.66	69.57	6.77
More than one hour per day	6.09	19.13	25.22	66.92	7.86
Computer Hours#					
One hour or less per day	4.89	18.55	23.45	69.41	7.15
More than one hour per day	8.38	20.56	28.94	64.13	6.93
Videogames Hours#					
One hour or less per day	5.12	18.78	23.90	68.83	7.26

More than one hour per day	6.32	18.96	25.28	68.25	6.48
Pocket Money#					
Some pocket money	5.11	18.68	23.78	68.35	7.87
No pocket money	5.56	18.94	24.51	69.08	6.41
Fizzy Drinks					
Yes	6.68	18.92	25.59	67.12	7.29
No	4.44	18.74	23.19	69.81	7.00
Potato chips					
Yes	5.18	18.02	23.21	69.54	7.25
No	5.52	19.71	25.23	67.80	6.97
French fries					
Yes	6.30	18.08	24.38	68.13	7.50
No	4.93	18.74	23.67	69.81	7.00
Other Junk Food					
Yes	4.69	17.946	22.63	70.04	7.33
No	7.09	21.16	28.25	65.19	6.56
Frequency of Exercise					
2 times or less	6.63	20.89	27.52	64.48	8.00
3-4 times	5.63	18.80	24.43	69.22	6.35
Almost everyday	4.76	18.07	22.83	70.04	7.14
Birth weight*					
Birth weight <2.5 KG	6.08	15.21	21.29	65.40	13.31
Birth weight 2.5 to 4.0 KG	4.79	18.47	23.26	68.96	7.78
Birth weight >4 KG	7.19	20.68	27.88	68.49	3.63

Source: Analysis of GUI data.[12]

A closer examination of Table 1 reveals some interesting patterns in obesity rates. For example, while there is a fairly steep gradient in obesity rates between the 1st and 2nd income quintiles, those in the 3rd income quintile have higher rates of obesity than in the second. Furthermore, the rate of obese/overweight is higher in the 4th quintile of income than in the 2nd quintile, while the 1st and 3rd quintiles have very similar rates of obese/overweight children. Overall this suggests that the gradient when considering overweight and obese children together is not very steep until the top quintile of income. Moreover, the obvious difference in weight problems by income is in the 5th quintile versus everyone else. On the other hand however, the gradient of obesity in parental education is very apparent.

[12] Notes: The 'overweight/obese' BMI category combines the 'obese' and 'overweight' BMI categories. The total sample size is 6,926. For variables relating to the second parent, the number of observations is 5,874, as some children in the sample live in a household with only one parent. The functional forms of some variables in Table 1 differ from the functional forms used in Table 3. This is to facilitate interpretation in the former. Specifically, variables with a * are included in their logarithmic form in the decomposition analysis, while variables with a # are included as categorical variables.

In order to quantify the extent of this inequality in obesity and overweight/obese in Irish children, normalised concentration indices based on the Wagstaff normalisation were calculated and are presented in Table 2 for the obese and overweight/obese categories. The results confirm the existence of significant inequalities, particularly for childhood obesity, and both indices are statistically different from zero at the 1% level. Once again, the inequality measured by the concentration index for obesity is much greater than that for overweight/obese, confirming that as BMI category changes from overweight/obese to obese, so too do the associated socioeconomic inequalities. Table 2 also reports estimated concentration indices by gender. The estimates show that there are greater inequalities in obesity and overweight/obese for girls than boys, though these differences were not found to be statistically significant in our sample.

Table 2: Normalised concentration indices of obesity and overweight/obese

	Obese			**Overweight/Obese**		
	All	**Boys**	**Girls**	**All**	**Boys**	**Girls**
Concentration index	-0.168	-0.110	-0.197	-0.057	-0.034	-0.074
Standard error	0.030	0.046	0.038	0.016	0.024	0.021
T value	-5.64	-2.37	-5.24	-3.59	-1.44	-3.44
Sample size	6,926	3,555	3,571	6,926	3,555	3,571

Source: Analysis of GUI data.[13]

Koolman and van Doorslaer (2004) have written on the best way to intuitively interpret the value of the concentration index. They have stated that if a concentration index of, for example, -0.10 is computed, this means that if 10% of the health problem is transferred from the poorest half of the income distribution to the richest half, this will result in perfect

[13] Notes: Estimates based on sample of children with at least one parent in the household. The ‘overweight/obese’ BMI category combines the ‘obese’ and ‘overweight’ BMI categories.

equality. While we use a slightly different measure of inequality by normalising our index, using the above interpretation suggests that a redistribution of approximately 16.8% of the obesity rate from the poorest half of the income distribution to the richest half would result in perfect equality in the prevalence of childhood obesity. Obviously a reduction in the overall level of obesity, rather than this redistribution, would be preferable.

The results from the decomposition analysis are presented in Table 3. These results are presented as the contribution (Cont) of each individual variable to the overall inequality in the concentration index, with the percentage contribution given in parentheses. A residual term is observed for obesity of Cont=-0.033 (19.36%) for those in the larger sample, suggesting there is some unobserved heterogeneity present that affects the observed inequality. A residual term of Cont=-0.010 (16.26%) is found for the overweight/obese sample. This suggests that there are unobserved factors that are affecting inequalities to a greater degree as we move along the right tail of the BMI distribution, though the variables included do explain the vast majority of the inequality. In general the results were broadly similar between the overall sample and the 2 parent only sample[14].

Table 3: Decomposition of concentration indices of socioeconomic inequality

	Obese		**Overweight/Obese**	
	1 or 2 Parents	**2 Parents Only**	**1 or 2 Parents**	**2 Parents Only**
Number	6,926	5,869	6,926	5,869
CI (Actual)	-0.168	-0.174	-0.057	-0.065
Unadjusted CI (Predicted)	-0.135 (80.64%)	-0.122 (72.02%)	-0.047 (83.74%)	-0.054 (88.92%)
GCI (Residual)	-0.033 (19.36%)	-0.052 (28.98%)	-0.010 (16.26%)	0.010 (9.18%)
Ln(Equivalised Household Income)	**0.016 (-9.49%)**	**0.019 (-11.05%)**	**0.042 (-73.61%)**	**0.026 (-45.51%)**

[14] We also considered a number of other models with different subsets of explanatory variables and our key findings and conclusions did not change. The model presented was chosen on the basis of variables included in previous studies that examined childhood obesity and the variables available within the GUI dataset, as well as a number of goodness-of-fit measures. Details of these models and tests are available from the authors on request.

Socioeconomic Variables				
Socioeconomic Group				
SEG1	Base	Base	Base	Base
SEG2	0.029 (-17.47)	0.015 (-8.56)	0.011 (-19.47)	0.005 (-7.96)
SEG3	-0.010 (6.09)	-0.006 (3.30)	-0.003 (6.10)	-0.001 (2.26)
SEG4	-0.020 (11.61)	-0.009 (5.23)	-0.007 (12.02)	-0.002 (3.40)
SEG5	-0.044 (26.14)	-0.014 (8.03)	-0.018 (31.41)	-0.003 (5.24)
Parental Education				
Mother/P1: Degree or above	Base	Base	Base	Base
Mother/P1: Upper secondary	-0.004 (2.55)	-0.003 (1.78)	-0.001 (2.04)	-0.000 (0.37)
Mother/P1: Lower secondary or below	-0.021 (12.24)	-0.015 (8.87)	-0.007 (12.09)	-0.004 (6.19)
Father/P2: Degree or above	-	Base	-	Base
Father/P2: Upper secondary	-	-0.003 (1.99)	-	-0.002 (3.61)
Father/P2: Lower secondary or below	-	-0.017 (9.51)	-	-0.011 (16.70)
Overall	**-0.070 (41.16)**	**-0.052 (30.15)**	**-0.025 (44.18)**	**-0.018 (29.82)**
Household Variables				
Urban	-0.002 (0.94)	-0.001 (0.64)	-0.001 (2.23)	-0.001 (0.88)
Own Home	0.007 (-3.69)	-0.003 (1.68)	-0.002 (2.64)	0.003 (-4.54)
Grocery Shops	-0.000 (0.03)	0.000 (-0.12)	0.000 (-0.42)	0.000 (-0.50)
Recreational Facilities	-0.002 (1.24)	-0.002 (1.06)	0.000 (-0.57)	-0.000 (0.03)
Overall	**0.003 (-1.48)**	**-0.006 (3.26)**	**-0.003 (3.88)**	**0.002 (-4.13)**
Parental Age Variables				
Mother/P1: Age	-0.000 (0.07)	-0.010 (5.53)	0.000 (0.00)	-0.005 (7.99)
Father/P2: Age	-	0.004 (-2.13)	-	0.002 (-2.63)
Overall	**-0.000 (0.07)**	**-0.006 (3.40)**	**0.000 (0.00)**	**-0.003 (5.36)**
Parental Health Variables				
Parental BMI				
Mother/P1: Ln BMI	-0.040 (23.78)	-0.034 (19.25)	-0.027 (50.00)	-0.025 (43.79)
Father/P2: Ln BMI	-	-0.002 (1.20)	-	-0.002 (2.74)
Smoking Status				
Mother/P1: Smoke during pregnancy	-0.013 (7.41)	-0.009 (5.42)	-0.017 (29.18)	-0.014 (22.34)
Father/P2: Current smoker	-	-0.008 (4.31)	-	-0.006 (8.63)
Alcohol Use				
Mother/P1: Alcohol during pregnancy	-0.001 (0.49)	-0.000 (0.10)	-0.003 (4.97)	-0.004 (5.41)
Father/P2: Alcohol per week	-	-0.010 (5.62)	-	-0.002 (3.56)
Overall	**-0.054 (31.68)**	**-0.063 (35.90)**	**-0.047 (84.15)**	**-0.053 (86.47)**
Child Variables				
Male	-0.001 (0.37)	-0.001 (0.30)	-0.001 (1.37)	-0.002 (2.67)

Breastfed	-0.004 (2.45)	-0.002 (0.91)	-0.003 (4.85)	-0.001 (2.09)
Child's Health	-0.004 (2.07)	-0.005 (2.61)	-0.001 (1.76)	-0.001 (2.51)
Doctor Visits	-0.001 (0.42)	0.000 (-0.00)	-0.000 (0.41)	-0.000 (0.23)
Nights in Hospital	-0.002 (1.09)	-0.001 (0.36)	-0.001 (2.07)	0.000 (-0.43)
TV Hours	-0.010 (6.00)	-0.007 (4.05)	-0.008 (13.26)	-0.008 (14.39)
TV in Bedroom	-0.007 (4.10)	-0.004 (2.33)	-0.009 (16.27)	-0.007 (10.58)
Reading Hours	0.000 (-0.01)	0.000 (-0.13)	-0.000 (0.09)	-0.000 (0.04)
Computer Hours	0.002 (-1.24)	0.004 (-2.20)	0.001 (-1.45)	0.001 (-1.80)
Videogames Hours	-0.001 (0.83)	-0.001 (0.41)	0.001 (-1.42)	0.002 (-2.71)
Pocket Money	-0.002 (1.31)	-0.001 (0.30)	0.001 (-1.48)	0.002 (-3.02)
Fizzy Drinks	-0.004 (2.20)	-0.004 (2.02)	0.001 (-1.55)	0.001 (-1.79)
Crisps	0.002 (-1.17)	0.001 (-0.64)	0.002 (-3.87)	0.002 (-2.53)
Chips	-0.000 (0.07)	0.001 (-0.35)	0.002 (-4.22)	0.003 (-3.97)
Other Junk Food	-0.000 (0.03)	-0.000 (0.09)	-0.000 (0.09)	-0.000 (0.31)
Frequency of Exercise	-0.002 (1.27)	-0.003 (1.87)	-0.001 (1.74)	-0.002 (3.21)
Ln Birthweight	0.002 (-1.09)	0.003 (-1.57)	0.002 (-2.80)	0.002 (-2.87)
Overall	**-0.032 (18.70)**	**-0.020 (10.36)**	**-0.014 (25.14)**	**-0.011 (16.91)**

Source: Analysis of GUI data.[15]

Overall the results suggest that the majority of the inequality in childhood obesity is explained by parental level variables. As expected, socioeconomic status and parental education contribute a large percentage to obesity and overweight/obese inequalities (41.16% and 44.18% respectively in the larger sample). Income itself (in its logarithmic form) has a small and negative impact on obesity inequalities (Cont=0.016, -9.49%) when other socioeconomic variables are controlled for, but does contribute to a large (and negative) degree to overweight/obese inequalities (Cont=0.042, -73.61%)[16]. This result emphasises that in order to better understand the socioeconomic inequalities underpinning ill health (in this case childhood obesity), it is important to further decompose inequalities quantified in concentration indices rather than relying on the index alone. While it was expected that parental obesity may have a significant association with childhood obesity inequalities[17], it is

[15] Notes: The 'overweight/obese' BMI group combines the 'obese' and 'overweight' BMI groups. Results are represented as contributions with percentage contribution in brackets.
[16] Van Doorslaer et al. (2004) show results for doctor utilisation across Europe and find that this result (i.e. logarithmic income has a negative contribution) is not unique.
[17] Classen (2010) provides evidence of strong persistence of weight problems across generations which may affect economic mobility within families, while mother's BMI has been shown previously to be highly correlated with children's health status (Case et al., 2002).

noteworthy that it is mainly mother's BMI that contributes to inequality (within the 2 parent sample)[18] and that when added to other parental health traits, such as smoking and drinking habits, parental health is actually as large, or a larger contributor to both obesity (Cont=-0.054, 31.68%) and overweight/obese (Cont=-0.047, 84.15%) inequalities than any other group of variables, including income and parental education. Furthermore, while TV watching, having a TV in the bedroom, and fizzy drink consumption have some impact on the observed inequalities, overall there is a relatively low impact for the set of child variables considered. However, we do acknowledge that the diet-related questions in the dataset are not ideal and only detail consumption in the previous 24 hours. As such, they may not be a good reflection of previous diet.

4. DISCUSSION

This paper provides evidence of a large socioeconomic gradient in childhood obesity in the Republic of Ireland, confirming the findings in Layte and McCrory (2011) and adding to similar evidence from other countries (Stamatakis et al., 2010; Singh et al., 2010; Knai et al., 2012). It presents, for the first time, concentration indices of obesity (CI=-0.168) and overweight/obese (CI=-0.057) for Irish children, showing that the socioeconomic gradient is more pronounced for obese children. The extensive range of variables available within our dataset allows us to decompose the socioeconomic inequalities into their specific determinants, facilitating a more in-depth analysis and understanding of childhood obesity prevalence rates. It is important that the factors underpinning socioeconomic inequalities in children obesity prevalence rates are understood and this is the first time such a decomposition analysis has been undertaken for obesity in a childhood population in a developed country. The results suggest that obesity and overweight/obese vary considerably

[18] This could be a result of assortative mating. See, for example, Silventoinen et al. (2003).

across a range of socioeconomic, parental and household dimensions. Our findings are consistent with recent evidence on the association between parental BMI and childhood obesity (Keane et al., 2012), though we show that much of this correlation may in fact be due to the socioeconomic circumstances of the household.

The decomposition analysis undertaken demonstrates that parental-level variables, in particular, are the main determinants underpinning obesity inequalities in Irish children. As expected, parental BMI, especially mothers' BMI, is a very significant driver of childhood obesity inequalities. But the results also indicate that socioeconomic group and parental education, as well as smoking[19] and alcohol consumption, contribute the greatest proportions to socioeconomic inequalities in childhood obesity. Interestingly, given the focus of many public health campaigns in promoting healthy and active lifestyles amongst children, smoking and alcohol consumption among parents contribute an even greater proportion to the social gradient than do children's variables such as diet, exercise and sedentary activities. This result is important and may be missed through normal regression techniques. While the smoking and alcohol variables may reflect lower discount rates applied to future health by parents at the lower end of the income distribution, they may also be associated with more constrained food budgets, due to the greater relative proportion of income spent on items such as cigarettes, alcohol and inadequate nutrition.

While parental variables such as BMI and economic status are extremely important determinants of childhood obesity, the correlates of these variables and their interactions are complex and multifaceted. In 2005, the National Taskforce on Obesity presented a report on obesity in Ireland, with a range of recommendations in relation to education, diet, facilities

[19] There is an extensive literature showing an empirical relationship between smoking during pregnancy and childhood obesity (von Kries et al., 2002; Gorog et al., 2011).

and incentives from which to explicitly target obesity (National Taskforce on Obesity, 2005). The report expressed the view that since the causes and problems of obesity are numerous and multifaceted, so too must be the solutions. Internationally, the problem of childhood obesity is also receiving increased attention. Long seen as a problem among better-off families, more recent research suggests that socioeconomic variables can have a large impact on children's weight problems (Drewnowski and Darmon, 2005; Cawley, 2010). But as the results show here, it is inevitable that the trade-off between current and future quality of life made at the parental level will also impact significantly on their children. While policymakers highlight the issues with childhood obesity, the willingness to pay for efforts to reduce childhood obesity is heavily affected by how people perceive the problem (Cawley, 2008). Thus, framing the issue as a serious one for the public may well be important.

Previous research has highlighted that while childhood obesity prevalence may well be levelling off or declining, this is being accompanied by an increase in socioeconomic inequalities (Stamatakis et al., 2010). Our results show the importance of investigating these inequalities when analysing childhood obesity rates and illustrate the advantages of using concentration indices and decomposition techniques to do so. While this paper does not seek to investigate the impact of specific policies on childhood obesity rates, the results do suggest that both childhood obesity prevalence rates and inequalities are complex issues that require coordinated policy responses at both the child and parental level. Indeed, obesity is now understood as a multi-level societal problem driven by forces directly related to the child and their parents, but also associated with variables relating to, for example, schools and neighbourhoods (Story et al. 2008; Diez Roux and Mair 2010; Layte et al., 2011). Therefore, identifying relevant policy recommendations for addressing childhood obesity is likely to benefit from the use of multilevel modelling (hierarchical) approaches (Diez-Roux, 2000), something that is beyond the scope of this paper.

In considering our results and their policy implications, it is worth stressing that given the cross-sectional nature of the available data, the analysis is necessarily descriptive and does not attempt to identify causal pathways. This suggests that while important patterns have been identified in this paper, further work is required before direct policy interventions based on the findings should be pursued. Moreover, it is also important to highlight some issues in relation to some of the variables used in our analysis. For example, the variables used in relation to children's diet and exercise behaviours refer to the past 24 hours and past fortnight respectively and we may therefore be missing important information in this regard. Furthermore, responses to some of these questions may suffer from a 'social desirability bias', whereby parents feel more inclined to answer questions on a child's eating and exercising behaviour in a way that they perceive would be viewed more favourably by an interviewer. There may also be a 'Hawthorne effect', whereby an invitation to partake in the GUI interview triggers short-lived changes in parenting behaviours or shifts the focus of parental attention to the child's eating/exercising habits. In such situations, it is possible that these data issues may be impacting on our findings in relation to the child variables.

Notwithstanding these caveats, the overall finding that inequalities in child obesity and overweight rates are to a large extent explained by characteristics known also to affect parental income (parental occupational status, education, age, BMI, etc.) is important and also consistent with findings from previous research (Madden, 2013). Moreover, the finding that the variables used to proxy child behaviour contribute little to the observed inequalities is surprising and certainly warrants further study.

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Appendix: Description of Variables

Variable	Description	Mean	STD	Min	Max
Weight	Study child's measured weight in KGs	33.67	6.92	21	57
Height	Study child's measured height in metres	1.37	0.06	1.21	1.52
BMI	Weight/(Height*Height)	17.80	2.82	12.25	27.38
Equivalised Net Household Income	Total net income in the household divided by an equivalence scale based upon the number of people in the household. Equivalence scale equal to the addition of the number of individuals within the household with the value of 1 given to the first individual, 0.66 given to each subsequent individual and 0.33 given to each child in the household.	€20,672	€10,002	€5,379	€67,241
Socioeconomic Group	Categorical variable based on the reported occupation of the head of household: SEG1 = Professional Managers; SEG2 = Managerial and Technical; SEG3 = Non Manual; SEG4 = Skilled Manual; SEG5 = Semi-Skilled, Unskilled, Unclassified.	2.72	1.24	1	5
Parental Education	Categorical variable based on the highest educational attainment of parents/guardians in the household: Degree or above; Upper secondary; Lower secondary or below.	1.91	0.65	1	3
Household Location	Indicator variable for whether the household is located in an urban or rural area.	0.45	0.50	0	1
Own House	Indicator variable for whether one or both parents/guardians owns their home outright or through a mortgage.	0.84	0.36	0	1
Grocery Shops	Indicator variable for whether essential grocery shopping is available in or within relatively easy access of the local area.	0.93	0.24	0	1
Recreational Facilities	Indicator variable for whether essential recreational services suitable for a 9 year old are available in or within relatively easy access of local area.	0.59	0.49	0	1
Parental Age (Mother)	Age of mother at time of survey.	39.71	5.28	26	50
Parental (Father)	Age of father at time of survey.	42.00	5.08	22	50

Parental BMI (Mother)	Body mass index of mother.	26.04	4.75	16.07	48.91
Parental BMI (Father)	Body mass index of father.	27.92	3.87	17.14	47.38
Smoked During Pregnancy	Indicator variable for whether the mother smoked during pregnancy.	0.22	0.42	0	1
Current Smoker	Indicator variable for whether the father/second guardian smoked at the time of survey.	0.26	0.43	0	1
Alcohol During Pregnancy	Indicator variable for whether the mother drank during pregnancy.	0.39	0.49	0	1
Alcohol Use	Categorical variable for whether the father/second guardian: Never drinks alcohol; Drinks alcohol once a month or less; Drinks alcohol weekly or more.	2.52	0.66	1	3
Gender	Indicator variable based on whether child is male or female.	0.48	0.50	0	1
Breastfed	Indicator variable for whether the mother ever breastfed the child.	0.52	0.50	0	1
Child Health	Categorical variable for whether the parent/guardian considers the child to be: Very healthy; Healthy; Sometimes unhealthy.	1.27	0.47	1	3
Doctor Visit Last Year	Categorical variable for how many times the child visited a doctor in previous 12 months: Never; Once; Two or more times.	1.62	0.80	1	3
Nights in Hospital	Categorical variable for how many nights the child spent in hospital in previous 12 months: None; One; Two or more.	0.75	0.92	0	2
TV Hours	Indicator variable for whether the child watches TV more or less than 1 hour per day on average.	0.74	0.44	0	1
TV in Bedroom	Indicator variable for whether the child has a TV in their bedroom.	0.37	0.48	0	1
Reading Hours	Indicator variable for whether the child reads for pleasure more or less than 1 hour per day on average.	0.32	0.46	0	1
Computer Hours	Indicator variable for whether the child uses a computer more or less than 1 hour a day on average.	0.13	0.34	0	1
Videogame Hours	Indicator variable for whether the child plays videogames more or less than 1 hour a day on	0.18	0.39	0	1

	average.				
Pocket Money	Indicator variable for whether the child receives pocket money per week.	0.51	0.50	0	1
Fizzy Drinks	Indicator variable for whether the child had fizzy or diet drinks in previous 24 hours.	0.40	0.49	0	1
Crisps	Indicator variable for whether the child had crisps (potato chips) in previous 24 hours.	0.53	0.50	0	1
Chips	Indicator variable for whether the child had chips (French fries) in previous 24 hours.	0.30	0.46	0	1
Other Junk Food	Indicator variable for whether the child had biscuits, doughnuts, cake, pie or chocolate in previous 24 hours.	0.73	0.44	0	1
Frequency of Exercise	Categorical variable for whether the child partakes in exercise on average: 2 times or less per week; 3-4 times per week; Almost everyday.	2.36	0.79	1	3
Birth Weight	Study child's birth weight in kilograms	5.53	0.61	1.7	6.1

Source: Growing Up in Ireland codebook.