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Is the Intergenerational Transmission of Overweight 'Gender Assortative'?

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Abstract

Using almost two decades worth of data from the Health Survey for England, containing records of clinically measured weight and height, this paper studies whether parents and children's overweight (including obesity) is 'gender assortative'. Our findings suggest that the intergenerational transmission of parent's overweight differs by children's sex and is statistically different for fathers and mothers. We show that when the mother is obese, the transmission of overweight to pre-school is gender specific. Similarly, the influence of parental overweight among primary school (pre-school) varies by gender. Gender assortative overweight is stronger among pre-school age and school-aged children. The parent-child associations are large and precisely estimated, heterogeneous by children's age and sex and stronger among white children and children of older parents. These results point towards evidence of gender assortative intergenerational association of overweight.

Keywords: Gender-assortative transmission, gender assortative, Child Obesity, Child Overweight, Role Models, Inter-generational Transmission.

JEL: I18.

1. Introduction

The prevalence of overweight children is a growing health and socio-economic concern with far reaching consequences. Estimates from the International Association for the Study of Obesity indicate that the rates of overweight (including obesity) children aged 5-17 years in the United Kingdom (UK) are among the highest in Europe. Figure 1 suggests that the prevalence of overweight children in England has increased dramatically between 1991-2009 decades, with the trend tailing off around 2005. Although this figure suggests a higher obesity rate increase among children aged 11-15 than among those that were younger, the trends are comparable.

[Insert Figure 1 about here]

Studies reviewing the heritability of overweight suggest that at least 50% of the variation is environmental (Herrera *et al.*, 2011). Given that children, especially at younger ages, do not make autonomous health and food related choices, it is reasonable to hypothesize that that their caloric intake and level of physical activity correlates with that of their parents'. As early as three or four years of age, children's eating patterns are already sensitive to environmental cues about food intake (Nicklas *et al.*, 2001).

Nonetheless, we still have limited knowledge about the mechanisms underlying transmission of overweight. Currie and Moretti (2007) document evidence of the intergenerational transmission of birth weight from mothers and their children, even when controlling for sibling fixed effects. However, we do not know whether this effect remains at later ages, and whether maternal and paternal influences are systematically different for their male and female offspring, i.e. whether it is gender assortative. Evidence of 'gender assortative' transmission of overweight is relevant for the design of policy interventions, as parents might exert parental role modelling influences, and, more generally, as well as spillover effects on child overweight. Empirical evidence can help disentangle how sensitive children's overweight is to changes in parental overweight.

The main purpose of this paper is to provide evidence of gender specific inter-generational transmission of overweight (and obesity). To do so, we classify obesity and overweight of children based on the gender-age specific Body Mass Index cut-off points (Cole *et al*, 2000) and run a comprehensive series of tests. Previous studies provide some evidence that the probability of an adolescent being obese increases when one of the parents is obese, and the effect is

strengthened when both parents are obese (Coate, 1983; Hebebrand et al, 2000; Martin, 2008). The estimates of the intergenerational correlations typically range between 0.15 and 0.38 (Ahlburg, D., 1998; Classen, 2010; Classen and Thompson, 2016; Dolton, P. and Xiao, 2015, 2017). However, the mechanisms underpinning the child –parent weight association are still largely ignored, and most existing large enough datasets are limited by the way they measure overweight (self-reported vs clinically measured), sample size and time span, as well as the information at the disposable on parents. Further, most research focusing on such mechanisms does not examine child obesity as a measure of interest (Coneus and Spiess, 2012).

A clear challenge for this line of research is that both parents often exhibit similar characteristics due to assortative mating. That is, individuals with similar genotypes and/or phenotypes (such as body size, cognitive abilities, age, education, etc.) are more likely to get together (Silventoinen *et al.*, 2003). Thus, it is not always possible to truly distinguish the influence of the mother from that of the father. Our strategy to attempt to circumvent this problem is to distinguish the case in which both parents are overweight from when only one of them is. If the estimate of the BMI association when both parents are overweight is larger than the sum of estimates when only the father or only the mother are, this would be an indication that both being overweight might have a multiplicative effect. Note, however, that the verification of this hypothesis would require controlling for which parent has the leading role in taking care of children. As the data we use does not have a time-use section specifying the involvement of each member of the household, we cannot bring add this extra layer of analysis. That said, in 90% of English households, women are the primary carers (ONS, 2017). Hence, in the majority of our sample, differential gender effects are not just sex effects but carry the effect of gender culture.

To date, the evidence on gender assortative transmission of overweight is limited with some exceptions (Mostazir *et al.*, 2014 and Ajala *et al.*, 2011). A study using Danish data shows that the intergenerational transmission of overweight (BMI) remains stable in terms of mother to child whereas this correlation for father and child has increased over time (Ajslev *et al.*, 2015). In contrast, a study using Finnish data for children born at the onset of the obesity epidemic revealed that paternal and maternal effects were stronger for daughters than for sons (Jääskeläinen *et al.*, 2011). Other studies find that mother–child weight association is higher than the father-child equivalent (Whitaker *et al.*, 1997). Finally, recent research suggests again that there has been an increase in the correlation of father and child obesity and even a reduction

of the maternal link (Ajslev *et al.*, 2015). Hence, the evidence is mixed and, for the most part, is based on a short time frame, not always converging the steeper rise in the obesity and overweight, and most studies fail to account for a rich enough set of relevant socio-economic controls that could mediate the effect. This paper attempts to fill this gap in the literature.

2. Methods

2.1. Data

We employ data from the Health Survey for England (HSE), a cross-sectional, representative survey started in 1991, carried out annually since. The HSE contains detailed records on health and health-related behaviors, including weight (kg), height (meters), and BMI, alongside a long list of variables such as fruit and vegetable consumption, alcohol intake and smoking in adults and children living in private households in England. The measurements of height and weight in the HSE are measured either by the interviewer or a nurse, overcoming the common problem of measurement errors that accompany self-reported measures of weight and height, or that of their children. The survey also includes data on household socio-economic status alongside core information on all its members, including their relationship between each of the family members. This allows for an accurate analysis of children-parent health associations. More specifically, the HSE comprises records from both adults aged 16 as well as children aged 2-15 from 1997, and, since 2002, infants under the age of 2. Information about children younger than 13 years is reported by their parents, but children are present when the interviewer measures their height and weight. Those aged 8 and over are asked to complete a short self-completion booklet during the interview. Children aged 13-15 are interviewed directly, after permission is obtained from the child's parent or guardian but their measurements are taken by the interviewer. Some other measures such as waist and hip circumferences are taken during a nurse visit.

The sample of the HSE that we use in this study refers to the Health Survey for England Time Series Dataset 1991-2009 (Higgins *et al.*, 2012) coinciding with a period during which England experienced a significant rise in child obesity and overweight. Given that weight and height data are only available from 1997 and more recent data (measurement and controls) are not fully comparable, our last wave is that of 2009.

[Insert Table 1 about here]

Table 1 reports the summary statistics by child age group and Table A1 in the Appendix contains the descriptive statistics of the variables that we employ in the study. Our two

dependent variables are described in the top panel, namely obesity and overweight of children. We divide the children sample in three groups based on the fact that the determinants of overweight exert different effects across age groups due to changes in the parental, school and other environment influences, e.g. affecting the probability of exercise among other (Dehghan et al, 2005). We consider three age groups of children: pre-school (birth to 5 years), primary school (6 to 11years), and teenagers (12 to 16 years). The prevalence of obesity and overweight is higher for school-aged children (6-11 years of age) than for those in pre-school (under 6 years of age). Similarly, the prevalence of parental overweight and obesity is higher in the sample of pre-schoolers and teenagers, possibly partly due to the aging process of the parents but also possibly partially reflecting the so-called obesity epidemic. Our data also contains records on parental mental health (depression scale), full time education of both father and mother. Other control variables are age, sex and ethnicity. We also control for children's long-standing illnesses as this may entail different parental interactions. We include a measure of parental passive smoking as it captures the effect of a number of potential unobservable characteristics underpinning parental behavior, and could be a proxy for a number of other behavioral traits such as time and/or risk preferences. As it is common practice, we include additional controls for maternal and paternal socio-economic circumstances that can potentially influence the intergenerational transmission of overweight, i.e. parental education, household income, property ownership, living in a rural setting (as opposed to urban), and, family size.

2.2. Empirical Strategy

Our empirical strategy is based on a linearized health production function in which the latent overweight of a child is explained by non-genetic factors (age of the parents, their education and employment statuses, household income, type of dwelling and being exposed to passive smoke); the child's own characteristics (age, sex, ethnic group); and mutually exclusive indicator variables that take value 1 if both parents are overweight (obese); if only the mother is overweight (obese); or if only the father is overweight (obese). Assuming linearity, our main equation of interest is:

$$o_{ij}^{*} = \delta_0 + \delta_b o_{ij}^{b} + \delta_M o_{ij}^{M} + \delta_F o_{ij}^{F} + \theta X_{ij} + \beta Z_j + v_{ij}\, o_{ij}^{*} = \delta_0 + \delta_b o_{ij}^{b} + \delta_M o_{ij}^{M} + \delta_F o_{ij}^{F} + \theta X_{ij} + \beta Z_j + v_{ij} \quad , (1)$$

where $o_{ij}^{*} o_{ij}^{*}$ indicates the latent overweight (obese) of child i in household j; $o_{ij}^{b} i$ is an indicator variable for *both parents* of child i in household j being overweight (obese); o_{ij}^{M} o_{ij}^{M} takes value one if *only the mother* of child i in household j is overweight (obese); o_{ij}^{F} o_{ij}^{F} takes value one if *only the father* of child i in household j is overweight (obese); X_{ij} a vector of the child's characteristics - including sex; Z_j refers to a vector containing parents' characteristics and other confounding factors such as income or employment status. Some evidence suggests that socially disadvantaged people have less access and lower ability to choose healthy behaviors (Whitakeret al 1997). However, some of these effects are not linear, for instance Apouey and Geoffard (2016) show that a negative association between parental education and children's weight using two large French samples. Finally, another potential influence includes maternal employment, which may decrease maternal time available for overseeing children's activities, generally resulting in increased sedentary activities as opposed to activities that result in calorie spending (see Gwozdz *et al.*, 2013, for instance).

Finally, v_{ij} is the error term that captures the effect of unobservable factors such as potential genetics factors, shared environment or cultural attitudes, among other. Assuming normality of the error term, v_{ij} v_{ij} , the probability of observing that a child i in our sample is overweight or obese $(o_{ij} = 1(o_{ij} = 1)$ is the probability that the corresponding latent variable is positive. Therefore, in this framework, coefficients $\delta_b, \delta_M,$ and $\delta_F \delta_b, \delta_M,$ and δ_F will be estimates of the association between *both parents*, *only the mother* or *only the father* being overweight (obese) with the likelihood of a child being overweight (obese).

Our focus, in addition to examining the existence of intergenerational transmission of overweight, is to examine if it varies by children's sex and by age. Thus, we estimate several models that measure the magnitude and significance of the correlation between different measures of parental overweight (obesity) and that of their children by sex and age group using a full set of interactions. We then test whether significant differences exist between the associations obtained by sex, by age groups, and by age-sex combinations. We include linear, quadratic (reported) and cubic year terms to pick up potential time-related trends in obesity and overweight.

In the next section, we describe our benchmark results, followed by a number of extensions and robustness checks, including whether age-distance between parents and child, the child being a single child or the child's ethnicity affect our benchmark findings.

3. Results

Our results are reported in Tables 2 to 5. Each table displays estimates for three different parent-children combinations. The first panel of each table presents the results of the association between parents and child being overweight; the second panel relates parents' obesity and child's overweight; and, finally, the third panel presents the association of parents and children's obesity. Tables 2,3, and 4 contain three different specifications including a different number of controls. Table 3 reports the formal testing of the baseline results using t-test statistics and corresponding p-values of a battery of tests of equality of the coefficients presented in Table 2. Tables 4 and 5 display the estimates when controlling for being a single child, child-parents' age-difference and ethnicity, respectively.

In Table 2, the first set of results in each panel is obtained by estimating parsimonious models that include only parental overweight (obesity) and child's sex to avoid make sure our controls are just *controls* (and not alter much the effect of the variables of interest). The second specification in each panel incorporates whether the child is at school or whether the child is a teenager. Finally, the third set of results adds a full set of controls containing household size; the child having a long illness; being exposed to passive smoking; the child's ethnicity; whether the mother works full time; whether the parents are biological parents; whether the mother has mental health or health problems; whether the father has mental health or health problems; the parents' education; if the household lives in a rural dwelling; if they own their home; and the logarithm of the household income. Given that the dependent variable in all these models is discrete, taking values equal to 1 (when the child is overweight/obese) and to 0 (otherwise), we estimate our models using OLS (and probit specifications to robustness purposes) with robust standard errors and clustered at the household level (as we have several children in some of the households). However, upon confirming the linearity of our estimates, we compute the effect of interactions using OLS (see Ai and Norton, 2003). We have estimated the baseline model employing other alternative clustering strategies such as primary sampling units, but the results were not significantly different.

4.1 *Baseline results*

Table 2 presents the estimates of the benchmark models that control for sex and child's age group alongside other covariates. Table 3 and Table A2 report the result of tests of equality of some of the coefficients in Table 2.

[Insert Table 2 about here]

Results in Table 2 are consistent with the existence of a strong transmission of overweight and obesity when both parents are overweight or obese, the association is positive and significant for both males (main effect) and even larger for female children (interaction). However, the second column of each panel, which decomposes the effect by age-sex groups, shows that the likelihood of a pre-school male child (the omitted category) to be overweight is 19.8pp larger when both parents are overweight and 26.7pp when both parents are obese.

If only one parent is overweight, we find an increased probability that a pre-school male child is overweight (6.2pp because of the mother only, 7.1pp because of the father) or obese (12.9pp for mothers, 9.6pp for fathers). However, when the child is female, her likelihood of being overweight is 6.6pp higher when both parents are overweight and 9.3pp higher when they are both obese; if only her mother is overweight (obese), the likelihood of the female children being overweight is increased by 5.7pp (by 5.9pp). Importantly, and independently of the parental overweight, if a male child is in school age rather than in pre-school, his likelihood of being overweight or obese increases by 4.5pp. If the male child is a teenager instead, the likelihood increases are 3.9pp and 4.2pp, respectively.

The results in the second column of the third panel indicate that having obese parents increases the likelihood of having an obese pre-school male child (11.8pp), especially if she happens to be a girl (adding 5.6pp). In contrast, having an obese mother alone increases the likelihood of a pre-school male child being obese (by 4.7pp). This association is not significant if the offspring is a girl instead. Similarly, if only the father is obese, the likelihood of a pre-school male child being obese increases (by 3.3pp) but again being a girl does not have an additional statistically significant effect. Nevertheless, if only either the father or the mother is obese, their school-age or teenager sons have a smaller chance of being overweight or obese, and school age males have higher chances of being obese by 0.9pp than pre-school children, but being a teenager alone, does not affect the likelihood of obesity significantly.

When we examine the specific effect of transmission by age groups in the third column of each panel in Table 2, we uncover that males in their teens with both parents overweight or obese face an increased probability of being overweight (by 10.1pp and 17.0pp, respectively). In contrast, if only their father is overweight and they are in school instead, they have an increased probability of being overweight (by 4.4pp) but have lower chances of being obese than a pre-school male child (by 3.4pp). School-age female children with an overweight or obese mother have an increased likelihood of being overweight (by 11.8pp and 14.3pp, respectively) or obese (7.2pp). Female children in their teens with obese mothers are more likely to be overweight (by 16.6pp) or obese (by 8.6pp).

4.2 Formal Testing

We have then formally tested whether the transmission of overweight is gender -assortative, and whether the differences combination of coefficients reported in Table 2 are statistically significant. We report these tests in Tables A2 and Table A3 in the Appendix.[1] More specifically, we test the hypotheses (formally in brackets) presented in the following subsections:

4.2.1 The association of father's overweight and child's overweight is different by child's gender $(\delta_{F,i=Male} = \delta_{F,i=Female})$.

The association of the father's *overweight* and the *overweight* of his son is larger than that with that of his daughter as we can see by the t-test statistic of 0.05 and p-value of 0.028 (first column of the first panel of Table A2). The association of the father being *obese* with his son being *obese* is statistically different than the association with the obesity of his daughter (0.39 (0.01), first column, third panel). This is not true when the father is obese and the son or the daughter is overweight (first column, second panel).

4.2.2 The association of mother's overweight and child's overweight is different by child's gender $(\delta_{M,i=Male} = \delta_{M,i=Female})$

We find no evidence of a significant association of overweight of mothers on children overweight. The only exception is when the mother is obese in which case we document an association with male child overweight is larger than that with her daughter (0.06 versus 0.03, first column, second panel).

[1] Each question in the first column of Table A2 is associated with a null hypothesis of the equality of coefficients in Table 2.

*4.2.*3 The association of both parents overweight on child's overweight is different by child's gender $(\delta_{b,i=Male} = \delta_{b,i=Female})$

Formal testing suggests that the association between both parents being overweight (obese) with their offspring being overweight or obese is larger for sons than daughters (first column of all three panels).

4.2.4 The association between parents' overweight and child overweight differ by gender $(\delta_{M,i=Male} = \delta_{F,i=Female})$

We find that among female children, the association of the child's overweight or obesity with her mother's is larger than it is with her father's (first column of three panels), which is consistent with assortative transmission of overweight from mothers to daughters.

4.2.5 Parental effects differ by child age $(\delta_{pre-school} = \delta_{School} = \delta_{Teenage})$

Given that BMI changes through childhood and adolescence, including the effects of adiposity rebound and pubertal effects (German *et al*, 2015), we specifically test the age-specific associations by children's age group.

We find that when the father is obese, the likelihood that his son is overweight or obese is different between all age groups, except for male teenage and primary school-agers (second panel of Table A3). However, this is not the case among daughters, for whom the transmission does not vary by age group.

The association between maternal obesity and their son's overweight differs if the son is pre-school or not. When the mother is overweight, the association differs between teenage and primary school-aged sons. Similarly, the association of mothers and daughters' overweight is different between teenagers and primary school age children. More specifically, when the mother is obese, the association with the daughter's overweight differs for all age groups, except for female teenager and school-agers.

Finally, the associations of both parents' overweight with that of their sons do not differ by age except for preschoolers and teenagers. In contrast, the association of both parents being obese with their daughter being overweight differs by age group.

In sum, the transmission of obesity by both parents, just the father and just the mother, depend crucially on the gender of both the parent and child. The transmission seems slightly stronger for maternal than paternal overweight.

4.3 Single child heterogeneity

One potential mechanism underlying the results above could be that there is a single child in the family. Some research documents that single children have less healthy eating habits, and mothers are found to be more likely to be overweight (Kracht et al, 2019). Evidence from a single child policy in China suggests only children are more likely to be obese. Although some research documents that family size reduces childhood obesity (Datar, 2017), the effect is driven mainly by families with one child and Dasgupta and Solomon (2018) do not find evidence of exogenous family size driven by the birth of twins on child overweight. Table 3 reports evidence consistent with this hypothesis as we do not find evidence that being a single child has a statistically significant effect on the intensity of the intergenerational transmission of overweight. The only exception is when both parents are obese, in which case the probability of a single child being overweight increases by 8.6pp.

[Insert Table 3 about here]

4.4 Parental specific effects

In identifying the sources of overweight it is important to consider different factors influencing household heterogeneity that may explain overweight There is evidence of a significant parent-child association in the intake of fruit and vegetables (Bere, E and K.I. Klepp (2004) and, for fitness and food consumption, children observe and model their behavior after their parents', especially for fitness and food consumption, which are in turn largely gender specific (Perez-Pastor et al 2009).

Table 4 shows the gender specific association between parents' and children's overweight allowing a heterogeneous effect by parental age. In the first panel of Table 4, we focus on the effect of older mothers, i.e. who had the child when they were above 30 years of age. We find that whilst mothers over 30 at the time of birth are less likely to have overweight and obese children, if they are obese, they are more likely to have an overweight child (by 4.8pp). Similarly, mothers over the age of 30 at birth living in a household in which the father is overweight or obese are more likely to have overweight (by 5.0pp and 8.9pp, respectively) and

obese males (by 3.1pp) consistent with gender-assortative transmission effects, although if the offspring is a female child, these likelihoods are mainly insignificant.

In the second and third panels of Table 4 we focus on the distance in age between the mother and the child and the father and the child, respectively. We observe that, in general, the age distance has a negative effect on the likelihood of the child obesity. But, when both parents and the father alone is obese, the likelihood of the offspring being overweight or obese increases with the age distance. This association is intensified among daughters.

[Insert Table 4 about here]

4.5 Ethnicity effects

Finally, Table 5 reports the estimates of an ethnicity specific association between parents' and children overweight. Ethnicity is important as it carries out the effect of cultural traits and research has documented disparities in ethnicity, mainly between white and black children (Public Health England, 2019). More specifically, we compare the parental association for white (which overall exhibit lower probability of overweight) and nonwhite children. The picture that these findings depict is that while when both parents are obese (or when only the father is overweight) and white, the likelihood of child overweight increases by 0.12pp (0.05pp) but among male children alone.

[Insert Table 5 about here]

4. Conclusion and discussion

Drawing on clinically reported measures of overweight from the Health Survey for England (1996-2009), this paper studies the existence of intergenerational transmission of overweight, and specifically, we have tested the hypothesis of gender assortative transmission of overweight. Furthermore, we have examined the heterogenous assortative transmission of overweight by the age of the child, availability of siblings (single child) and ethnicity of the child (white ethnicity).

Consistently with the hypothesis of assortative transmission of overweight, we find that parental transmission of overweight is gender specific. Namely *the effects of fathers' overweight are systematically different than that of mothers among female children*. Our results suggest that when both parents are overweight, this exerts a reinforcing effect on the probability of child overweight. We show that when the mother is obese, the transmission of overweight to pre-school is gender specific. Similarly, the influence of parental overweight among primary school (pre-school) varies by gender. These results are strengthened under the presence of assortative mating by which parent share lifestyle preferences. Finally, we document stronger maternal effects consistent with previous literature (Patro, et al 2013).

Another important finding refers to the differences by *age groups*. When both parents are overweight the chances of their sons being overweight differs by age group. More specifically the effect among *teenagers, who have* lived with their parents for a longer time and had time, exhibit a stronger association with that of *both parents* (rather than to maternal or paternal specific effects) overweight than other age groups. Father specific effects differ across the age of the child and are different between male (teenage age) and female children (primary school age). This finding consistent with the fact that older children are more sensitive to social cues (Fehr *et al*, 2008), but the effect on overweight in different by gender.

Nonetheless, the results are of course limited by the potential influence of unobservable confounders that could bias our results. However, it is difficult to predict the effect size given that whilst some unobservable variation would underestimate our correlation (e.g., risk aversion), other such as genetic trait would lead to the opposite bias.

The implications of the study are important insofar they suggest to special attention to families where both parents are overweight, and to pay attention to gender and age-specific influences. Another important lesson is that policy interventions ought to target children heterogeneously by gender because environmental pressures are gender specific. Not only we find that parents overweight predicts that of their parents (which could be explained by genetic influences), but that such an association changes with children's age and, it appears to be especially strong for older parents and children at school age and during teenage years. Interventions should place special attention to school-age female children, particularly when their mother is obese. Finally, consistently with other studies, we find that lower income parents are more at risk of being

overweight, and so are their children. Hence, interventions should discriminate by income to exert a stronger effectiveness.

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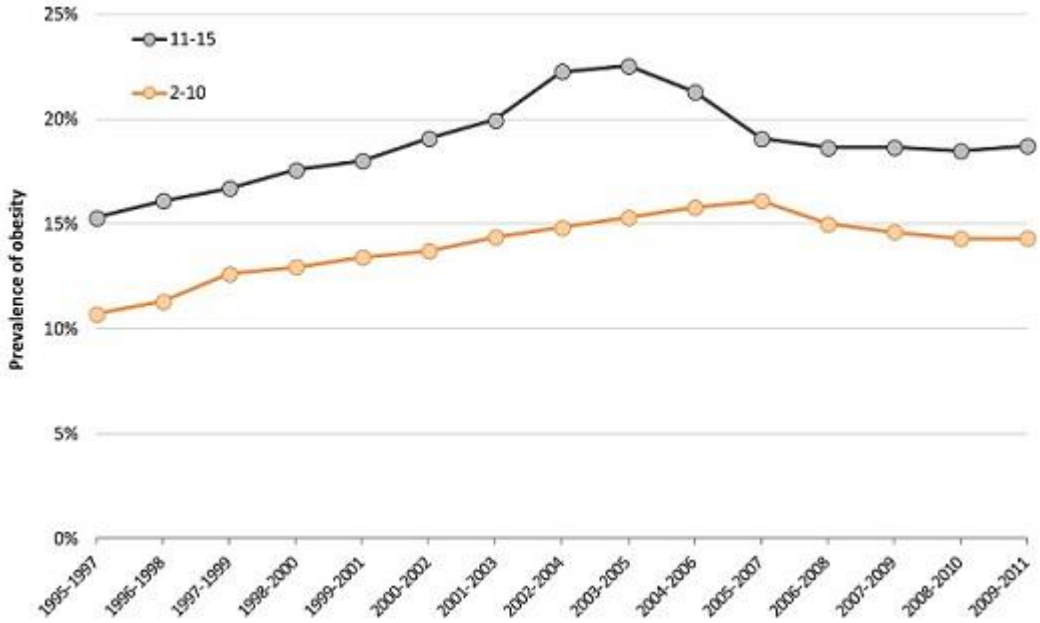
Figures and Tables

Figure 1. Patterns of child obesity in England 1995- 2011 by age group



Source: Public Health England, 2013
http://www.noo.org.uk/NOO_about_obesity/child_obesity/UK_prevalence

Table 1. Summary Statistics for the Full Sample and by Child Age Group

Variable	Definition	Pre-School (0-5 years)	School Child (6-11 years)	Teenager Child (12-16 years)	Total
	Number of observations	2907	7423	4071	14401
Overweight	Obese (%)	4.9	6.1	5.8	5.8
	Overweight (%)	19.3	24.8	24.8	23.7
Age	Mean Age	4.02	9.01	14.46	9.55
	Std. Dev	(0.80)	(1.98)	(1.10)	(3.95)
Sex	Female Child (%)	50.2	49.3	48.4	49.2
	Male Child (%)	49.8	50.7	51.6	50.8
Child Health	Long Standing Illness (%)	18.1	19.4	21.5	19.7
Ethnicity	White (%)	78.1	79.2	79.4	79
	Black (%)	5	4.2	3.6	4.2
	Ind/Pak/Bang (%)	4.1	3.9	3.8	3.9
	Other (%)	12.8	12.6	13.2	12.8
Parents' Overweight	Mother Obese (%)	18	21.8	24.4	21.8
	Father Obese (%)	20.4	22.9	25.2	23
	Mother Overweight (%)	48.5	53	59	53.8
	Father Overweight (%)	68.4	71.7	74.6	71.9
Parents' Smoking	Passive Smoking (%)	21.5	25.5	27.9	25.4
Parents' Mental Health	Mother (%)	2.8	2.6	3	2.8
	Father (%)	1.8	1.7	2.3	1.9
Parents' Full Time	Mother Works Full Time (%)	59	70.8	77.4	70.3
	Father Works Full Time	90.57	90.04	89.04	89.86
Parents' Education	Mother Not specified Education	9.6	13.2	17.1	13.6
	Mother Vocational Qualification	33.1	29.6	27.5	29.7
	Mother A/O Level or above	48.8	49.4	46.7	48.5
	Mother Secondary education	6.5	6	6.3	6.2
	Father Not specified Education	12.3	14.5	19.5	15.5
	Father Vocational Qualification	42.1	40.1	38.7	40.1
	Father A/O Level above	38.4	38.7	35.2	37.7

	Father Secondary	6.1	5.5	5.1	5.5
Rural	Living in Rural Area	19.7	22.1	23	21.9
Family size	Number members in household	3.2	4.1	4.4	4.336
Dwelling	Property ownership	77.9	81	83.1	81
Income	Mean Income	£ 34,906	£ 36,462	£ 35,361	£ 35,837
	Std dev	(41459.61)	(43,203.12)	(48,846.61)	(41,459.61)

Source: Health Survey for England1997-2009.

Note: This table provides a description of the summary statistics of the child and parents of children in the HSE sample, broken down by child age group (pre-school 0-5 years of age, school child 6-11 years of age, and 12-16 which refer to teenage children). Our descriptive statistics include age, gender, child health, ethnicity, parent's overweight, parent's smoking, parents mental health, household size, rurality, parent' education, property ownership, income (£).

Table 2: Fully interacted Linear Probability Model of Child and Parents' Overweight

Child is:	Overweight			Overweight			Obese		
Parents are:	(2.1) Overweight	(2.2) Overweight	(2.3) Overweight	(2.4) Obese	(2.5) Obese	(2.6) Obese	(2.7) Obese	(2.8) Obese	(2.9) Obese
Both Overweight	0.201***	0.198***	0.146***	0.266***	0.267***	0.150***	0.122***	0.118***	0.065**
	(0.013)	(0.013)	(0.026)	(0.024)	(0.024)	(0.050)	(0.016)	(0.016)	(0.032)
Both Overweight x Female Child	0.071***	0.066***	0.076**	0.098***	0.093***	0.220***	0.051**	0.056**	0.093*
	(0.018)	(0.019)	(0.033)	(0.033)	(0.034)	(0.075)	(0.025)	(0.026)	(0.056)
Only Mother Overweight	0.071***	0.062***	0.059*	0.132***	0.129***	0.126***	0.050***	0.047***	0.046***
	(0.016)	(0.016)	(0.031)	(0.016)	(0.016)	(0.016)	(0.009)	(0.009)	(0.009)
Mother Overweight x Female Child	0.058**	0.057**	-0.008	0.064***	0.059***	-0.066*	0.019	0.020	-0.044**
	(0.023)	(0.024)	(0.041)	(0.022)	(0.023)	(0.038)	(0.014)	(0.014)	(0.020)
Only Father Overweight	0.070***	0.071***	0.038*	0.099***	0.096***	0.095***	0.032***	0.033***	0.032***
	(0.013)	(0.013)	(0.023)	(0.015)	(0.015)	(0.015)	(0.008)	(0.008)	(0.008)
Father Overweight x Female Child	0.015	0.014	0.035	0.051**	0.051**	0.016	-0.004	-0.006	-0.014
	(0.018)	(0.018)	(0.028)	(0.021)	(0.022)	(0.037)	(0.011)	(0.011)	(0.019)
Female Child	0.011	0.015	0.014	0.029***	0.031***	0.030***	0.013***	0.015***	0.015***
	(0.013)	(0.014)	(0.014)	(0.008)	(0.008)	(0.008)	(0.004)	(0.004)	(0.004)
School Child		0.045***	0.012		0.045***	0.048***		0.009*	0.014**
		(0.009)	(0.017)		(0.009)	(0.011)		(0.005)	(0.006)
Teenager Child		0.039***	-0.011		0.042***	0.049***		0.001	-0.001
		(0.011)	(0.020)		(0.011)	(0.014)		(0.006)	(0.007)
Both Overweight x School Child			0.048*			0.093			0.036
			(0.029)			(0.057)			(0.039)
Both Overweight x School x Female Child			0.006			-0.103			-0.020
			(0.034)			(0.084)			(0.067)
Both Overweight x Teenage Child			0.101***			0.170***			0.084*
			(0.033)			(0.066)			(0.044)
Both Overweight x Teenage Child x Female			-0.038			-0.233**			-0.084
			(0.038)			(0.094)			(0.070)
Mother Overweight x School Child			-0.015			-0.049***			-0.024***
			(0.036)			(0.016)			(0.009)
Mother Overweight x School x Female Child			0.118**			0.143***			0.072***
			(0.047)			(0.041)			(0.023)
Mother Overweight x Teenage Child			0.045			-0.067***			-0.036***
			(0.043)			(0.022)			(0.010)
Mother Overweight x Teenage Child x Female			0.017			0.166***			0.086***
			(0.054)			(0.047)			(0.027)

Father Overweight x School Child			0.044*			-0.034***			-0.025**
			(0.026)			(0.012)			(0.006)
Father Overweight x School x Female Child			-0.033			0.042			0.003
			(0.029)			(0.039)			(0.020)
Father Overweight x Teenage Child			0.041			-0.055***			-0.012
			(0.030)			(0.016)			(0.008)
Father Overweight x Teenage Child x Female			-0.013			0.050			0.026
			(0.034)			(0.046)			(0.024)
Intercept	0.099***	0.116	0.150	0.158***	0.105	0.117	0.027***	-0.015	-0.010
	(0.009)	(0.098)	(0.099)	(0.006)	(0.097)	(0.097)	(0.002)	(0.059)	(0.059)
Observations	14277	13592	13592	14277	13592	13592	13592	13592	13592

Notes: This table provides the estimates of a fully interacted model of child overweight explained by parental overweight, and gender and child age group. All specifications control for household size; the child having a long illness; being exposed to passive smoking; the child's ethnicity; whether the mother works full time; whether the parents are biological parents; whether the mother has mental health or health problems; whether the father has mental health or health problems; the parents' education; if the household lives in a rural dwelling; if they own their home; and, the logarithm of the household income.

*Significant at 10%, ** Significant at 5% and ** Significant at 1% level.

Table 3 Parent to Child Overweight (including Obesity) - Single Child

	(1)	(2)	(3)
Parents are:	Overweight	Obese	Obese
Child is:	Overweight	Overweight	Obese
Single Child	0.052	-0.004	0.009
	(0.039)	(0.038)	(0.020)
Female	0.013	0.036***	0.016***
	(0.014)	(0.009)	(0.004)
Single Child x Female	0.000	-0.022	0.010
	(0.051)	(0.050)	(0.029)
Both Overweight	0.201***	0.264***	0.114***
	(0.014)	(0.025)	(0.017)
Both Overweight x Female	0.074***	0.093***	0.057**
	(0.020)	(0.034)	(0.026)
Both Overweight x Single Child	-0.017	0.086*	0.042
	(0.047)	(0.046)	(0.026)
Both Overweight x Single x Female	-0.046	-0.004	-0.019
	(0.065)	(0.063)	(0.039)
Mother Overweight	0.062***	0.128***	0.046***
	(0.017)	(0.016)	(0.009)
Mother Overweight x Female	0.056**	0.057**	0.017
	(0.025)	(0.023)	(0.014)
Mother Overweight x Single Child	-0.002	0.018	-0.036
	(0.059)	(0.057)	(0.025)
Mother Overweight x Single Child x Female	0.027	0.033	0.064
	(0.085)	(0.082)	(0.048)
Father Overweight	0.070***	0.094***	0.031***
	(0.014)	(0.015)	(0.008)
Father Overweight x Female	0.022	0.053**	-0.003
	(0.019)	(0.022)	(0.011)
Father Overweight x Single Child	0.008	0.056	0.009
	(0.048)	(0.046)	(0.024)
Father Overweight x Single Child x Female	-0.070	-0.069	-0.063*
	(0.066)	(0.063)	(0.033)
Intercept	0.154*	0.150*	-0.009
	(0.091)	(0.090)	(0.053)
Observations	13592	13592	13592

Note: This table provides the estimates of a fully interacted model of child overweight with explanatory variables including being a single child. All specifications control for household size; the child having a long illness; being exposed to passive smoking; the child's ethnicity; whether the mother works full time; whether the parents are biological parents; whether the mother has mental health or health problems; whether the father has mental health or health problems; the parents' education; if the household lives in a rural dwelling; if they own their home; and, the logarithm of the household income.

*Significant at 10%, ** Significant at 5% and ** Significant at 1% level.

Table 4. Parent to Child Overweight (including Obesity) - Control for Child-Parent/s Age differences

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Mother over 30			Age distance: Mother & child			Age distance: Father & child		
Parents:	Overweight	Obese	Obese	Overweight	Obese	Obese	Overweight	Obese	Obese
Child:	Overweight	Overweight	Obese	Overweight	Overweight	Obese	Overweight	Overweight	Obese
Both Overweight	0.224***	0.288***	0.140***	0.213***	0.234***	0.120***	0.195***	0.233***	0.119***
	(0.013)	(0.019)	(0.013)	(0.057)	(0.020)	(0.014)	(0.054)	(0.020)	(0.014)
Mother Overweight	0.088***	0.143***	0.054***	0.127*	0.109***	0.041***	0.153***	0.109***	0.041***
	(0.016)	(0.013)	(0.007)	(0.068)	(0.013)	(0.008)	(0.065)	(0.013)	(0.008)
Father Overweight	0.065***	0.106***	0.027***	0.081	0.086***	0.020***	0.103*	0.086***	0.020***
	(0.013)	(0.012)	(0.006)	(0.057)	(0.012)	(0.006)	(0.054)	(0.012)	(0.006)
Female children	0.056***	0.056***	0.024***	0.027**	0.027**	0.015**	0.030**	0.030**	0.011*
	(0.009)	(0.009)	(0.005)	(0.014)	(0.014)	(0.006)	(0.014)	(0.014)	(0.007)
Mother over 30	-0.019	-0.087***	-0.023***						
	(0.015)	(0.012)	(0.005)						
Both Overweight x Father ¿30	0.012	0.135***	0.026***						
	(0.023)	(0.019)	(0.010)						
Mother Overweight x Mother ¿30	0.004	0.048**	0.016						
	(0.029)	(0.024)	(0.012)						
Father Overweight x Mother ¿30	0.050**	0.089***	0.031***						
	(0.022)	(0.018)	(0.008)						
Both Overweight x Mother ¿30 x Female children	0.016	0.021	0.010						
	(0.024)	(0.023)	(0.013)						
Mother Overweight x Mother over 30 x Female children	-0.001	-0.009	-0.010						
	(0.033)	(0.033)	(0.018)						
Father Overweight x Mother over 30 Female children	-0.034	-0.033	-0.032***						
	(0.021)	(0.021)	(0.010)						
Age distance parent-child				-0.000	-0.003***	-0.001***	0.000	-0.003***	-0.001
				(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
Both Overweight x Age distance				-0.000	0.004***	0.001***	0.000	0.004***	0.001***
				(0.002)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)
Mother Overweight x Age distance				-0.002	0.001*	0.000	-0.003	0.001**	-0.000
				(0.002)	(0.001)	(0.000)	(0.002)	(0.001)	(0.000)
Father Overweight x Age distance				-0.000	0.002***	0.000***	-0.001	0.002***	0.000*
				(0.002)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)
Both Overweight x Age distance* Female				0.002***	0.002***	0.001*	0.002***	0.002***	0.001***
				(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
Mother Overweight x Age distance * Female				0.001*	0.001	0.000	0.001	0.001	0.001
				(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)

Father Overweight x Age distance* Female				0.000	0.000	-0.000	-0.000	-0.000	-0.000
				(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
School Child	0.044***	0.042***	0.008	0.044***	0.040***	0.007	0.045***	0.041***	0.008
	(0.009)	(0.009)	(0.005)	(0.009)	(0.009)	(0.005)	(0.009)	(0.009)	(0.005)
Teen	0.040***	0.039***	-0.000	0.039***	0.034***	-0.002	0.039***	0.035***	-0.001
	(0.011)	(0.011)	(0.006)	(0.011)	(0.011)	(0.006)	(0.011)	(0.011)	(0.006)
Intercept	0.104	0.104	-0.012	0.122	0.145	0.005	0.108	0.132	-0.002
	(0.099)	(0.098)	(0.060)	(0.106)	(0.099)	(0.060)	(0.106)	(0.099)	(0.060)
Observations	13588	13588	13588	13588	13588	13588	13588	13588	13588

Note: This table provides the estimates of a fully interacted model of child overweight with explanatory variables including child's age and gender and also controls for the mother being over 30 years of age and the distance between the child's age and that of his/her parents. All specifications in in this table control for household size; the child having a long illness; being exposed to passive smoking; the child's ethnicity; whether the mother works full time; whether the parents are biological parents; whether the mother has mental health or health problems; whether the father has mental health or health problems; the parents' education; if the household lives in a rural dwelling; if they own their home; and, the logarithm of the household income. *Significant at 10%, ** Significant at 5% and ** Significant at 1% level.

Table 5. Heterogeneous Transmission by Ethnicity

	(1)	(2)	(3)
Parents are:	Overweight	Obese	Obese
Child is:	Overweight	Overweight	Obese
White	-0.001	-0.090***	-0.045***
	(0.029)	(0.025)	(0.014)
Female	0.012	0.023	0.012
	(0.028)	(0.016)	(0.009)
White Child x Female	0.003	-0.008	-0.003
	(0.032)	(0.023)	(0.011)
Both Overweight	0.217***	0.217***	0.100***
	(0.028)	(0.026)	(0.017)
Both Overweight x Female	0.066*	0.077**	0.053**
	(0.039)	(0.036)	(0.026)
Both Overweight x White	-0.022	0.119***	0.034***
	(0.032)	(0.017)	(0.008)
Both Overweight x White x Female	0.002	0.038	0.010
	(0.045)	(0.023)	(0.012)
Only Mother Overweight	0.071**	0.104***	0.038***
	(0.032)	(0.017)	(0.010)
Mother Overweight x Female	0.052	0.042*	0.014
	(0.048)	(0.025)	(0.015)
Mother Overweight x White	-0.012	0.023	-0.001
	(0.037)	(0.019)	(0.008)
Mother Overweight x White x Female	0.009	0.045	0.021
	(0.055)	(0.028)	(0.014)
Only Father Overweight	0.088***	0.071***	0.026***
	(0.029)	(0.016)	(0.008)
Father Overweight x Female	0.008	0.050**	-0.006
	(0.039)	(0.022)	(0.012)
Father Overweight x White	-0.022	0.049***	0.006
	(0.033)	(0.015)	(0.006)
Father Overweight x White x Female	0.008	0.002	0.002
	(0.044)	(0.021)	(0.009)
Intercept	0.180**	0.205**	0.018
	(0.091)	(0.089)	(0.053)
Observations	13356	13356	13356

Note: This table provides the estimates the model of child overweight with explanatory variables that include child's ethnicity. All specifications in in this Table control for household size; the child having a long illness; being exposed to passive smoking; the child's ethnicity; whether the mother works full time; whether the parents are biological parents; whether the mother has mental health or health problems; whether the father has mental health or health problems; the parents' education; if the household lives in a rural dwelling; if they own their home; and, the logarithm of the household income. *Significant at 10%, ** Significant at 5% and ** Significant at 1% level.

Appendix

Table A1. Means and Standard deviation				
Variable	**Description**	**Observations**	**Mean**	**(Std. Dev)**
Obese	Child measured BMI - Obese =1	14401	0.057	-
Overweight	Child measured BMI – Overweight =1	14401	0.237	-
Obesity both	Parent measured BMI –Both Obese =1	14401	0.072	-
Overweight Both	Parent measured BMI –Both Overweight =1	14401	0.405	-
Mother Obese	Parent measured BMI –Mother Obese =1	14401	0.144	-
Mother Overweight	Parent measured BMI – Mother Overweight=1	14401	0.132	-
Father Obese	Parent measured BMI – Father Obese=1	14401	0.157	-
Father Overweight	Parent measured BMI – Father Overweight=1	14401	0.312	-
Female	Female Child =1	14401	0.492	-
Pre-school Children	Pre-school Child=1	14401	0.796	
School Children	Primary School Aged Child=1	14401	0.515	-
Teenage Children	Teenage Child =1	14401	0.281	-
Long Standing Illness	Children has a long Standing Illness =1	14401	1.803	-
Smoking	Passive Smoking (One of the parents smoke) =1	14401	0.252	-
Mother FT Employment	Mother works full time employment	14401	0.702	-
Mother Biological	Biological mother=1	14401	1	-
Father Biological	Biological Father=1	14401	0.892	-
Maternal Mental Disorder	No Maternal mental health	14401	0.935	
Paternal Mental Disorder	No Paternal mental health	14401	0.629	
Maternal education	Maternal education attainment Scale 1-5	14401	1.533	0.873
Paternal Education	Paternal education attainment Scale 1-5	14401	1.371	0.851
Rural	Household residence is in a rural area=1	14401	0.219	-
Flat Ownership	Household owns a propert1	14401	0.81	-
Income (logs)	Household income (logs)	14401	9.327	3.072
Household Size	Household size	14401	4.336	0.901
Waves (Time)	Time (1997=1, 2009=n)	14401	6.362	3.659
White	White ethnicity	14401	0.79	-

Source: From waves 1997-2009 of the Health Survey for England.

Table A2. Test of equality of linear combination of coefficients

	Overweight Parents to Overweight Children		Obese Parents to Overweight Children		Obese Parents to Obese Children	
	All age groups	All controls	All age groups	All controls	All age groups	All controls
Father effect: Female different to Male Child						
• All Children	**0.05 (0.028)**		No		0.39 (0.01)	
• Pre-school Child		No		0.079 (0.04)		0.04 (0.02)
• School Child		**0.07 (0.03)**		No		No
• Teen Child		No		No		No
"Mother effect": Female different to Male Child						
• All Children	No		0.06 (0.03)		No	
• Pre-school Child		No		0.19 (0.04)		0.08 (0.02)
• School Child		**No**		**No**		**No**
• Teen Child		**No**		**No**		No
"Both joint effect": Female different to Male Child						
• All Children	**0.13 (0.02)**		0.17 (0.05)		0.06 (0.037)	
• Pre-school Child		No		No		No
• School Child		0.11 (0.03)		0.12 (0.07)		**No**
• Teen Child		0.20 (0.04)		0.33 (0.09)		**0.14 (0.07)**
Father effect different than Mother's for Male Child						
• All Children	No		No		No	
• Pre-school Child		No		No		No
• School Child		**-0.038 (0.02)**		No		No
• Teen Child		No		No		No
Father effect different than Mother's for Female Child						
• All Children	**0.34 (0.017)**		**0.040 (0.022)**		**0.041 (0.013)**	
• Pre-school Child		No		**-0.080 (0.11)**		No
• School Child		**0.069 (0.024)**		0.085 (0.123)		**0.053 (0.019)**
• Teen Child		No		0.098 (0.121)		NO

Note: This table shows the results of the t-test statistics and corresponding p-values for the statistically significant results of the associated tests of equality of linear combinations of coefficients after estimations in columns 2 and 3 of each panel in Table 2. Null hypothesis for each question is coefficients are not different (H_o=0). 'No" refers the case where we reject the joint significance of the linear combination of equality of coefficients, so that equality (no difference) cannot be rejected. See notes in Table 2.

Table A3. Test of Equality of Coefficients of transmission by age groups

	Overweight Parents to Overweight Children	Obese Parents to Overweight Children	Obese Parents to Obese Children
Father's effect different by age for Males?			
• Pre-school	No	0.129 (0.019)	0.057 (0.010)
• Pre-teen	No	0.149 (0.02)	0.044 (0.011)
• Teen-school	No	No	No
Father's effect different by age for female children?			
• Pre-school	No	No	No
• Pre-teen	No	No	No
• Teen- school	No	No	No
Mother's effect different by age for Males?			
• Pre- school	No	0.17 (0.02)	0.070 (0.013)
• Pre-teen	No	0.19 (0.02)	0.081 (0.012)
• Teen- school	0.06 (0.03)	No	No
Mother's effect different by age for female children?			
• Pre-school	No	-0.20 (0.07)	-0.11 (0.03)
• Pre- school	No	-0.23 (0.03)	-0.12 (0.04)
• Teen-school	-0.01 (0.047)	No	No
Both effect different by age for Males?			
• Pre- school	0.09 (0.05)	No	No
• Pre-teen	No	No	No
• Teen- school	0.05 (0.02)	No	No
Both effect different by age for female children?			
• Pre- school	No	0.32 (0.15)	NO
• Pre-teen	0.11 (0.06)	0.45 (0.15)	NO
• Teen- school	-0.04 (0.03)	-0.013 (0.073)	NO

Note: This table shows the t-test statistics and corresponding p-values for the statistically significant results of the associated tests of equality of coefficients in columns 3 of each panel in Table 2. Null hypothesis for each question is no difference (H_o=0). We apply a test of equality of coefficients in Stata 14.0. We report NO when the null of equality (no difference) is rejected. See notes in Table 2.