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Abstract

We study the intergenerational transmission of overweight, that is the association between parental overweight and that of their offspring and examine whether it is gender-assortative or whether the maternal or paternal overweight is related differently to daughters than to sons. We draw from 15 years of data from the Health Survey for England, which contains records of clinically measured weight and height of a representative sample of English children. Our findings are consistent with the existence of a strong intergenerational transmission of overweight from parents to their offspring. These effects are stronger among white children and older parents. We also find support for the existence of an unanticipated gender-assortative transmission of obesity and overweight, namely, a stronger association of father's overweight and that of his daughters that is statistically significantly different than that of the mother (with her daughters). Our evidence suggests a higher likelihood of being overweight among girls when their mother is obese.

JEL-Codes: I120.

Keywords: gender assortative parental transmission, child obesity, child overweight, role models, inter-generational transmission.

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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 (EASO) 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 displays an increase in child overweight in England, one of the world countries where child obesity has risen at a faster pace, though we find that the trend tails off around 2005. In addition, Figure 1 shows a higher obesity rate increase children aged 11-15 than those of younger age, though overall trends are comparable. This paper is devoted to understanding the root causes of such obesity trends.

[Insert Figure 1 about here]

Provided that genetics are unlikely to have changed dramatically over the past thirty years (see Herrera *et al*, 2011 for a review), environmental changes are likely to be driving the effect, though they are still not well understood. Given that children, especially at younger ages, do not make autonomous health and food related choices, one of the most pressing hypotheses underpinning child obesity epidemic refers to the existence of *shifts* in the intergeneration transmission of overweight. That is, if the correlation between parents and children's overweight has changed over time, one can hypothesize that the family environment might exert a crucial influence in such a change (Anderson *et al,* 2007). Children's caloric intake, dietary habits and level of physical activity are associated with that of their parents' social norms (Anderson and Butcher, 2006), and as early three or four years of age, children's eating patterns are already sensitive to environmental cues about food intake (Nicklas *et al*, 2001) and role modelling (Richtie *et al*, 2005). However, we still have limited knowledge about the mechanisms underlying the influence of the child specific family environment on the child's dietary habits. One of the main theories is that transmission is assortative by gender, that is, maternal and paternal influences have different effects on boys than on girls.

The main purpose of this paper is to empirically test for the existence of an intergenerational transmission of overweight and obesity. To do so, we first study the presence of differential maternal and paternal transmission of overweight by child's gender and then allow differential effects across children ages.[i] Our main focus is on natural children (as in Classen

and Hokayem, 2005, Classen, 2010 and Costa-Font and Gil, 2013). Other studies focusing on biological relatives do not find evidence of strong, shared environmental effect, but they focus on Body Mass Index (BMI) and do not distinguish overweight from obesity (Cawley and Meyerhoefer, 2012).

We find that there is a strong intergenerational transmission of overweight from parents to their offspring. The effects are stronger for white children and when the parents are older. We also find evidence of a non-trivial gender-assortative transmission of obesity and overweight as the association of father's obesity (overweight) with that of his daughter is statistically significantly different than that of the mother with her daughter's. We find an increased likelihood of overweight among girls when the mother is obese, which differs by age group.

The remainder of the paper is organised as follows: next section provides the background literature. Section three reports the data and empirical strategy. Section four provides the results and section five contains a discussion and concludes.

2. Intergenerational and gender-assortative transmission

Literature spanning several decades provides some evidence that indicates that the probability of an adolescent to be obese increases when one of the parents is obese, and the effect is strengthened when both parents are obese (Coate, 1983; Currie *et al*, 2007; Hebebrand *et al,* 2000, Martin 2008; Anderson *et al*, 2007; Classen and Hokayem (2005). The estimates of the intergenerational correlations typically range between 0.15 and 0.38 (Ahlburg, 1998, Classen 2010). However, the mechanisms underlying the correlation are still largely ignored and the datasets are limited either by the way they measure overweight (self-reported vs clinically measured), sample size and time span, as well as the information available for both parents.

Central to our explanation is the role modelling effects parents exert on children's behaviours and lifestyle (the 'like begets likes') by passing on eating behaviours (e.g., portion sizes, time of sugar intakes, regularity of fat intake, etc.) and physical exercise habits. However, parents may potentially play different roles depending on their gender, which would pave the way to gender-assortative transmission. The literature consistently points out that there is a stronger maternal effect than that of the father (Pareo *et al*, 2013). An explanation is that nutrition responsibility is still predominately a female dominated sphere, that is, a considerably higher proportion of women are responsible for food shopping

and preparation compared with men (Caraher *et al*, 1999, Lake *et al*, 2006). Nevertheless, a clear challenge for this line of research is that parents often exhibit similar characteristics due to assortative mating, by which individuals with similar genotypes and/or phenotypes such as body size, cognitive abilities, age, education, etc. are more likely to partner (Silventonen *et al*, 2003, Allison *et al*, 1996). Thus, it is challenging to distinguish mother's influence from that of the father. Our strategy to attempt to circumvent this problem is to distinguish whether both parents are overweight or obese from only the mother or only the father being so.

In identifying the sources of obesity it is important to consider household heterogeneity (Nicklas *et al*, 2001). There is evidence of a significant parent-child association for fruit and vegetable intake (Bere *et al*, 2004) and, even when parents do not impose strict behavioural rules, children observe and model their behaviour after their parents, especially for fitness and food consumption, which are in turn largely gender specific (Pérez-Pastor *et al*, 2015).

Although there exists some paediatric medical literature reporting gender-assortative transmission of overweight (Mostazir *et al*, 2014; Ajala *et al*, 2011, for instance), there is limited consensus on its existence. A study using Danish data shows that the intergenerational transmission of overweight remains quite stable in terms of mother to child, whereas the father to child BMI correlation has increased over time (Ajslev *et al*, 2014, 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). Similarly, Whitaker *et al* (2010) find that mother–child's weight association is higher than father-child's one (Whitaker *et al*, 2010). However, recent research suggests there has been an increase in the correlation of father and children's obesity and a reduction of the maternal link (Ajslev *et al*, 2014). In general, the relevant existing evidence is based on short periods of time and does not include a rich enough set of relevant socio-economic controls.

In addition to direct parental transmission, confounding factors such as poverty, low income or female employment may play a role in the parental-children correlation of overweight (Classen, 2010, Costa-Font and Gil, 2013, Cavaco *et al,* 2014), even when including only adopted children (Hruschka and Brewis, 2013). Some evidence suggests that socially disadvantaged people have less access and ability to choose healthy behaviours (Wickrama *et al*, 1999). However, some of these effects are not linear. Baum II and Ruhm (2007) find that an additional year of maternal education reduces obesity by an average of 0.2 kg/m^2.

Apouey and Geoffard (2016) find that the association between parental education and child body weight follows an inverted U-shape, widening from birth to age 8, and narrowing later.

Maternal employment may decrease maternal time available for overseeing children's activities, which generally results in increased sedentary activities as opposed to activities that result in calorie spending. Anderson *et al* (2003) suggest that there is a causal linkage of maternal employment on child's weight, especially for mothers working long hours, although they did not focus on the intergenerational transmission of obesity and overweight. An exception is Costa-Font and Gil (2013) who find that, after accounting for the intergenerational transmission, mother's labour market participation only explains obesity among boys but not girls.

3. Data and Methods

3.1. *Data*

We exploit the Health Survey for England (HSE). This cross-sectional survey started in 1991 and has been carried out annually since then. The HSE is a representative survey that contains detailed health and health-related behaviours, including weight, height 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 validated by a nurse, overcoming the problem of measurement error of these values present in other surveys containing children (Cawley *et al*, 2015). The survey also contains the socio-economic status of the household and core information on all its members, including their relationship. Our pooled cross-section dataset results from merging information contained in the thirteen waves that span from 1997 to 2009. The HSE contains records from adults aged 16 and over, since 1995 has also included children aged 2-15, and since 2002 - infants under 2. The information on children younger than 13 years is reported by their parents. During an interview with each person in the household, a nurse clinically measures the height and weight of survey participants alongside other variables.

[Insert Table 1 about here]

Table 1 reports the summary statistics by child age group and Table A1 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 in three groups: pre-school, primary school children and teenagers. The

prevalence of obesity and overweight is higher for school-aged children than for those in pre-school. Similarly, the prevalence of parental overweight and obesity is higher in 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 contains also information on parental health, full time education of both father and mother. Other control variables are age, gender, two measures of health (long standing illness and passive smoking) and ethnicity. As it is common practice, we include additional controls for maternal and paternal education, alongside income, flat ownership, the rural nature of the neighbourhood and family size.

3.2. *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's income, type of dwelling and being exposed to passive smoke); the child's own characteristics (age, gender, 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 as follows:

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

where o_{ij}^{*} indicates the latent overweight (obese) of child i in household j; o_{ij}^{b} is an indicator variable for *both parents* of child i in household j being overweight (obese); o_{ij}^{M} takes value one if *only the mother* of child i in household j is overweight (obese); 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 gender; Z_j is a vector with the parents' characteristics and and v_{ij} is the error term. Assuming normality of the error term, v_{ij}, the probability of observing that a child i in our sample is overweight or obese ($o_{ij} = 1$) is the probability that the corresponding latent variable is positive. Therefore, in this framework, coefficients $\delta_b, \delta_M,$ 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 a child being overweight (obese).

Our main focus, in addition to examining the existence of intergenerational transmission of overweight, is to examine if it varies by children's gender and by age. Thus, we estimate a number of models that measure the magnitude and significance of the correlation between different measures of parental overweight (obesity) and that of their children by gender and age group using a full set of interactions. We then test whether there are significant differences between the associations obtained by gender, by age groups, and by age-gender combinations. We include linear, quadratic and cubic time trends. We report the results obtained using a quadratic trend as the results are almost identical.

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.

4. Results

Our results are reported in Tables 2 to 6. Each table contains estimates for three different parent-children combinations. The first panel of each table presents the results for 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 and 5 contain three different specifications including a different number of controls. Table 3 presents the T-test statistics and corresponding p-values of a battery of tests of equality of the coefficients presented in Table 2. Table 4, 5 and 6 present the estimates when controlling for being a single child, child-parents' age difference and ethnicity, respectively.

In Tables 2, the first set of results in each panel is obtained estimating parsimonious models that include only parental overweight (obesity) and child's gender to avoid the common problem of *bad* controls. The second specification in each panel incorporates whether the child is at school or whether he or she 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 natural 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 probit specifications with robust standard errors and clustered by household (as we have several children in some of the households).

4.1 *Baseline results*

Table 2 presents the estimates of the benchmark models that control for gender and child's age group and 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 boys (main effect) and even larger for girls (interaction). However, the second column of each panel, which does not decompose the effect by age-gender groups, shows that the likelihood of a pre-school boy (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 increase in the chances that a pre-school boy 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 a girl, 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 girl being overweight is increased by 5.7pp (by 5.9pp). This is consistent with previous evidence from Britain suggesting that girls exercise less and spend more time at home compared to boys of equivalent age. Importantly, and independently of the parental overweight, if the boy is in school age rather than in pre-school, his likelihood of being overweight or obese is increased by 4.5pp. If the boy 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 boy (11.8pp), and even more if she happens to be a girl (adding 5.6pp). In contrast, having an obese mother alone increases the likelihood of the pre-school boy being obese (by 4.7pp) but this does not change statistically significantly if the offspring is a girl instead. Similarly, if only the father is obese, the

likelihood of the pre-school boy 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 boys 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 boys 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 boy (by 3.4pp). School-age girls with an overweight or obese mother have an increased likelihood of being overweight (by 11.8pp and 14.3pp, respectively) or obese (7.2pp). Girls in their teens with obese mothers are more likely to be overweight (by 16.6pp) or obese (by 8.6pp).

[Insert Table 3 about here]

4.2 Formal Testing

Tests in Table 3 and Table A2 are useful to establish if the transmission is gender-assortative, e.g., if the differences in some key coefficients in Table 2 are statistically significant. Each question in the first column of Table 3 is associated with a null hypothesis of the equality of coefficients in Table 2. More specifically, we attempt to test the hypotheses presented in the following subsections:

4.2.1 The effect of father's overweight on child overweight is different by child's gender.

The association of the father's *overweight* and the *overweight* of his son is larger than 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 3). 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 dad is obese and the son or the daughter is overweight (first column, second panel).

4.2.2 The effect of mother's overweight on child overweight is different by child's gender.

We do not find evidence of a differential association when mothers are overweight. The only exception is evidence that when the mother is obese, the association with the likelihood of her son being overweight is larger than that with her daughter (0.06 (0.03), first column, second panel).

4.2.3 The effect of both parents overweight on child overweight is different by child's gender.

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 Maternal and paternal effects on child overweight are different from each other by gender.

We find that among girls, the association of her own 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.

We find that when the dad is obese, the likelihood that his son is overweight or obese is different between all age groups except when we compare teenage boys and schoolboys (second panel of Table A2). This is not the case when the offspring is a female, for which 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 from the rest of the groups. When the mother is overweight, the association differs between teenage sons and school-aged sons. For girls, the association of mother□s and daughter's overweight is different between teenagers and school-girls. When the mother is obese, the association with the daughter being overweight or obese is different between all age groups except between teenager and school-aged girls. Finally, the association of both parents' overweight with that of their son is different when we compare pre-school to school- boys and teenage boys to school boys but not for between pre-schoolers and teenagers. The association of both parents being obese with their daughter being overweight is different by age group.

In sum, Table 3 provides evidence that the transmission of obesity by both parents, just the father and just the mother tends to depend crucially on the gender of the parent and of the offspring. This is slightly less strong when the dad is overweight.

4.3 Single child heterogeneity

One potential mechanism underlying the above results could be that there is a single child in the family. Single children are more likely to attract their parents' undivided attention and, thus, potentially receive more food than they need. Table 4 discards this hypothesis. As shown in this table, 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 4 about here]

4.4 Parental age effects

Table 5 shows the gender specific association between parents and children s overweight allowing a heterogeneous effect by parental age. In the first panel of Table 5, 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 that were above 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 boys (by 3.1pp) consistent with gender-assortative transmission effects, although if the offspring is a girl, these likelihoods are mainly insignificant.

In the second and third panels of Table 5 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 or the father alone is obese, the likelihood of the offspring being overweight or obese increases with the age distance. This association is intensified when the offspring is a girl.

[Insert Table 5 about here]

4.5 Ethnicity effects

Finally, Table 6 contains the estimates of an ethnicity specific association between parents' and children overweight. The picture that such findings depict is that while being white reduces the probability of a boy being obese, when both parents are (or only the father is) obese, the likelihood of their offspring being overweight is increased, the chances of being obese are only affected by both parents being obese but not the father or the mother alone.

[Insert Table 6 about here]

5. Conclusion

Drawing on clinically reported measures of overweight from the Health Survey for England (1996-2009), we have examined the existence of intergenerational transmission of overweight, and specifically, we have tested the hypothesis of gender-assortative transmission of overweight from parents to offspring and whether such transmission alters by the age group of the child. We have run a number of robustness checks and specifically have examined the effect of being a single child, parental age and ethnicity.

We find evidence of an intergenerational transmission of overweight when both parents are overweight. One interpretation is that both parents being overweight has a reinforcing effect on children. These results are strengthened under the presence of assortative mating by lifestyle preferences.

Our results are heterogeneous by gender and across age groups. We find non-trivial evidence of assortative transmission. That is, the effect of fathers' overweight is different than that of mothers for girls (especially by raising their chances of being overweight). When the mother is obese, the transmission of overweight and obesity to pre-school boys is different than that to girls. The transmission of overweight if the father is overweight to school-aged children varies by gender. If instead he is obese, gender differences only apply to pre-school children.

Teenagers appear to be more receptive to parental transmission of both parents overweight but not maternal or paternal specific effects, which is consistent with the fact that, at that age, children are more sensitive to social cues (Fehr *et al*, 2008), although this is due also possibly to a cumulative pattern in the transmission of health behaviours from parents to their children. Other findings suggest some evidence of a specific effect of dad's overweight among boys, and especially, fathers overweight on boys among those with older fathers and mothers.

We also obtain important results suggestive of a heterogeneous transmission by age group for boys and girls separately. Mainly, both parents being overweight increases the chances of their son being overweight differently by age group. When only one parent is overweight or obese, the differences by age apply when the father is obese on overweight sons and when the mother is obese on both boys and girls.

The implications of the study are that policies aimed at reducing children's obesity should place special attention to families, where both parents are obese or overweight as they are likely to influence their children up and above the obvious genetic influence. Another important lesson is that policies ought to heterogeneously target boys and girls by age groups insofar as environmental pressures are both gender and age specific. That is, parental effects exert a different influence on boys (teenage age) and girls (school age) as the above described results suggest.

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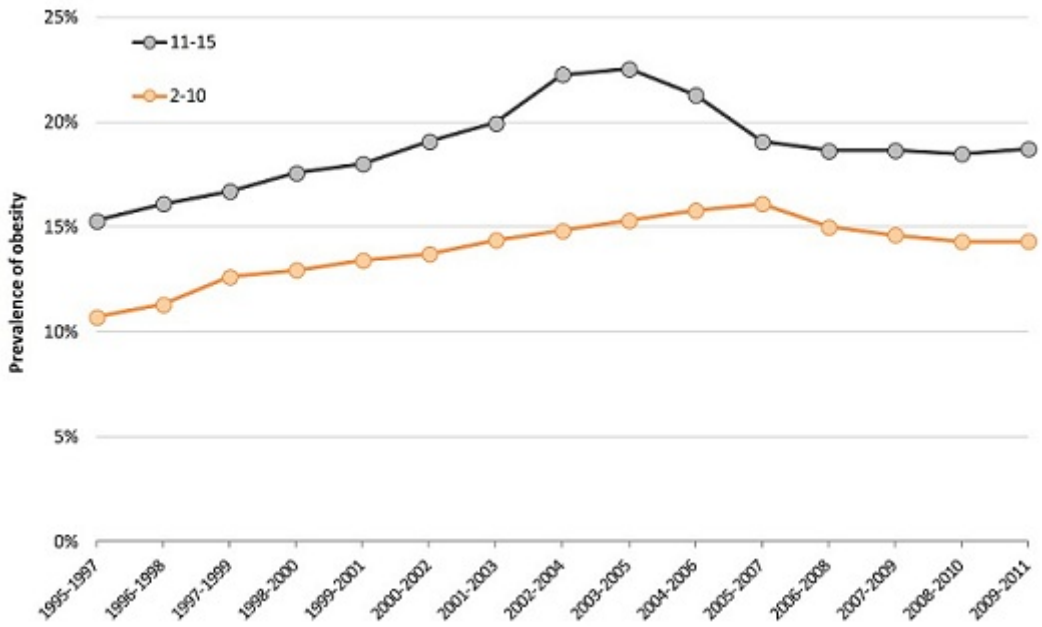
Figures and Tables

Figure 1. Patterns of child obesity in England 1995- 20011 by age group



Source: Public Health England, 2013
http://www.noo.org.uk/NOO˙about˙obesity/child˙obesity/UK˙prevalence

[i] Other studies drawing on smaller samples that included adopted children find evidence of cultural transmission (Costa-Font *et al*, 2015), but due to sample size restrictions, cannot evaluate children's age specific effects

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

		Child Type			
	Number of observations	Pre-School (2907)	Child (7423)	Teenager (4071)	Total (14401)
Overweight	Obese (%)	4.9	6.1	5.8	5.8
	Overweight (%)	19.3	24.8	24.8	23.7
Age	Mean number of years	4.02	9.01	14.46	9.55
	Standard Deviation number of years	(0.80)	(1.98)	(1.10)	(3.95)
Gender	Girl (%)	50.2	49.3	48.4	49.2
	Boy (%)	49.8	50.7	51.6	50.8
Health	Long Standing Illness (%)	18.1	19.4	21.5	19.7
	Passive Smoking (%)	21.5	25.5	27.9	25.4
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	Mother Obese (%)	18	21.8	24.4	21.8
	Dad Obese (%)	20.4	22.9	25.2	23
	Mum Overweight (%)	48.5	53	59	53.8
	Dad Overweight (%)	68.4	71.7	74.6	71.9
Parents' Mental Health	Mother (%)	2.8	2.6	3	2.8
	Dad (%)	1.8	1.7	2.3	1.9
Parents' Full Time	Mother Works Full Time (%)	59	70.8	77.4	70.3
	Dad Works Full Time	90.57	90.04	89.04	89.86
Parents' Education	MumEd:NA	9.6	13.2	17.1	13.6
	MumEd:Nvq5-HE	33.1	29.6	27.5	29.7
	MumEd:A/O Level	48.8	49.4	46.7	48.5
	MumEd:CSE	6.5	6	6.3	6.2
	MumEd:Foreign	1.9	1.8	2.3	2
	DadEd:NA	12.3	14.5	19.5	15.5
	DadEd:Nvq5-HE	42.1	40.1	38.7	40.1
	DadEd:A/O Level	38.4	38.7	35.2	37.7
	DadEd:CSE	6.1	5.5	5.1	5.5
	DadEd:Foreign	1.1	1.2	1.4	1.2
Nuclear Family	Family of 3	14.1	8.8	13.6	11.2
Rural	Living in Rural Area	19.7	22.1	23	21.9
Dwelling	Own the flat	77.9	81	83.1	81
Income	Mean	£ 34,906.63	£ 36,462.20	£ 35,361.18	£ 35,836.94
	Standard Deviation	(41459.61)	(43,203.12)	(48,846.61)	(41,459.61)

Summary statistics of main variables by children's age group.
Source: *Health Survey for England.*

Table 2 General: All OLS Models Obese to Overweight

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Parents:	Overweight	Overweight	Overweight	Obese	Obese	Obese	Obese	Obese	Obese
Child:	Overweight	Overweight	Overweight	Overweight	Overweight	Overweight	Obese	Obese	Obese
Both Ob/Ov	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 Ob/Ov - Girl	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 Mum Ob/Ov	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)
Mum Ob/Ov - Girl	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 Dad Ob/Ov	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)
Dad Ob/Ov - Girl	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)
Girl	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)
Teen		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 Ob/Ov - School			0.048*			0.093			0.036
			(0.029)			(0.057)			(0.039)
Both Ob/Ov - School Girl			0.006			-0.103			-0.020
			(0.034)			(0.084)			(0.067)
Both Ob/Ov - Teen			0.101***			0.170***			0.084*
			(0.033)			(0.066)			(0.044)
Both Ob/Ov - Teen Girl			-0.038			-0.233**			-0.084
			(0.038)			(0.094)			(0.070)
Mum Ob/Ov - School			-0.015			-0.049***			-0.024***
			(0.036)			(0.016)			(0.009)
Mum Ob/Ov - School Girl			0.118**			0.143***			0.072***
			(0.047)			(0.041)			(0.023)
Mum Ob/Ov - Teen			0.045			-0.067***			-0.036***
			(0.043)			(0.022)			(0.010)
Mum Ob/Ov - Teen Girl			0.017			0.166***			0.086***
			(0.054)			(0.047)			(0.027)
Dad Ob/Ov - Teen			0.041			-0.055***			-0.012
			(0.030)			(0.016)			(0.008)
Dad Ob/Ov - Teen Girl			-0.013			0.050			0.026
			(0.034)			(0.046)			(0.024)
Dad Ob/Ov - School			0.044*			-0.034***			-0.025***
			(0.026)			(0.012)			(0.006)
Dad Ob/Ov - School Girl			-0.033			0.042			0.003
			(0.029)			(0.039)			(0.020)
˙cons	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

Note: Robust Standard Errors in Parentheses
Specifications in Columns 2 and 3 of each panel 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 natural 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.

	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
Dad's effect: Girls different to boys?						
All	**0.05 (0.028)**		No		0.39 (0.01)	
pre		No		0.079 (0.04)		0.04 (0.02)
sch		**0.07 (0.03)**		No		No
teen		No		No		No
Mum's effect: Girls different to boys?						
All	No		0.06 (0.03)		No	
pre		No		0.19 (0.04)		0.08 (0.02)
sch		**No**		**No**		**No**
teen		**No**		**No**		No
Both effect: Girls different to boys?						
All	**0.13 (0.02)**		0.17 (0.05)		0.06 (0.037)	
pre		No		No		No
sch		0.11 (0.03)		0.12 (0.07)		**No**
teen		0.20 (0.04)		0.33 (0.09)		**0.14 (0.07)**
Dad's effect different than Mum's for boys?						
all	No		No		No	
pre		No		No		No
sch		**-0.038 (0.02)**		No		No
teen		No		No		No
Dad's effect different than Mum's for girls?						
all	**0.34 (0.017)**		**0.040 (0.022)**		**0.041 (0.013)**	
pre		No		**-0.080 (0.11)**		No
sch		**0.069 (0.024)**		0.085 (0.123)		**0.053 (0.019)**
teen		No		0.098 (0.121)		NO

Table 4 All OLS Models Obese to Overweight - Single Child

	(1)	(2)	(3)
Parents:	Overweight	Obese	Obese
Child:	Overweight	Overweight	Obese
Single Child	0.052	-0.004	0.009
	(0.039)	(0.038)	(0.020)
Girl	0.013	0.036***	0.016***
	(0.014)	(0.009)	(0.004)
Single Child and Girl	0.000	-0.022	0.010
	(0.051)	(0.050)	(0.029)
Both Ob/Ov	0.201***	0.264***	0.114***
	(0.014)	(0.025)	(0.017)
Both Ob/Ov and Girl	0.074***	0.093***	0.057**
	(0.020)	(0.034)	(0.026)
Both Ob/Ov and Single Child	-0.017	0.086*	0.042
	(0.047)	(0.046)	(0.026)
Both Ob/Ov Single Girl	-0.046	-0.004	-0.019
	(0.065)	(0.063)	(0.039)
Only Mum Ob/Ov	0.062***	0.128***	0.046***
	(0.017)	(0.016)	(0.009)
Mum ObOv and Girl	0.056**	0.057**	0.017
	(0.025)	(0.023)	(0.014)
Mum Ob/Ov and Single Child	-0.002	0.018	-0.036
	(0.059)	(0.057)	(0.025)
Mum Ob/Ov Single Girl	0.027	0.033	0.064
	(0.085)	(0.082)	(0.048)
Only Dad Ob/Ov	0.070***	0.094***	0.031***
	(0.014)	(0.015)	(0.008)
Dad Ob/Ov and Girl	0.022	0.053**	-0.003
	(0.019)	(0.022)	(0.011)
Dad Ob/Ov and Single Child	0.008	0.056	0.009
	(0.048)	(0.046)	(0.024)
Dad Ob/Ov Single Girl	-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

Notes: Robust Standard Errors in Parentheses
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 natural 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.

Table 5: All OLS Models Obese to Overweight - 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 Ob/Ov	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)
Mum Ob/Ov	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)
Dad Ob/Ov	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)
Girl	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)
Mum over 30	-0.019	-0.087***	-0.023***						
	(0.015)	(0.012)	(0.005)						
Both Ob/Ov Mum over 30	0.012	0.135***	0.026***						
	(0.023)	(0.019)	(0.010)						
Mum Ob/Ov Mum over 30	0.004	0.048**	0.016						
	(0.029)	(0.024)	(0.012)						
Dad Ob/Ov Mum over 30	0.050**	0.089***	0.031***						
	(0.022)	(0.018)	(0.008)						
Both Ob/O Mum over 30 Girl	0.016	0.021	0.010						
	(0.024)	(0.023)	(0.013)						
Mum Ob/Ov Mum over 30 Girl	-0.001	-0.009	-0.010						
	(0.033)	(0.033)	(0.018)						
Dad Ob/Ov Mum over 30 Girl	-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 Ob/Ov * Age dist				-0.000	0.004***	0.001***	0.000	0.004***	0.001***
				(0.002)	(0.000)	(0.000)	(0.002)	(0.000)	(0.000)
Mum Ob/Ov * Age dist				-0.002	0.001*	0.000	-0.003	0.001**	-0.000
				(0.002)	(0.001)	(0.000)	(0.002)	(0.001)	(0.000)
Dad Ob/Ov * Age dist				-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 Ob/Ov * Age dist * girl				0.002***	0.002***	0.001*	0.002***	0.002***	0.001**
				(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
Mum Ob/Ov * Age dist * girl				0.001*	0.001	0.000	0.001	0.001	0.001
				(0.001)	(0.001)	(0.000)	(0.001)	(0.001)	(0.000)
Dad Ob/Ov * Age dist * girl				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: Robust Standard Errors in Parentheses

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 natural 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.

Table 6 : Transmission Controlling for Ethnicity

	(1)	(2)	(3)
Parents:	Overweight	Obese	Obese
Child:	Overweight	Overweight	Obese
White	-0.001	-0.090***	-0.045***
	(0.029)	(0.025)	(0.014)
Girl	0.012	0.023	0.012
	(0.028)	(0.016)	(0.009)
White Child and Girl	0.003	-0.008	-0.003
	(0.032)	(0.023)	(0.011)
Both Ob/Ov	0.217***	0.217***	0.100***
	(0.028)	(0.026)	(0.017)
Both Ob/Ov and Girl	0.066*	0.077**	0.053**
	(0.039)	(0.036)	(0.026)
bothwhite	-0.022	0.119***	0.034***
	(0.032)	(0.017)	(0.008)
Both Ob/Ov White Girl	0.002	0.038	0.010
	(0.045)	(0.023)	(0.012)
Only Mum Ob/Ov	0.071**	0.104***	0.038***
	(0.032)	(0.017)	(0.010)
Mum ObOv and Girl	0.052	0.042*	0.014
	(0.048)	(0.025)	(0.015)
Mumo White	-0.012	0.023	-0.001
	(0.037)	(0.019)	(0.008)
Mum Ob/Ov White Girl	0.009	0.045	0.021
	(0.055)	(0.028)	(0.014)
Only Dad Ob/Ov	0.088***	0.071***	0.026***
	(0.029)	(0.016)	(0.008)
Dad Ob/Ov and Girl	0.008	0.050**	-0.006
	(0.039)	(0.022)	(0.012)
dadowhite	-0.022	0.049***	0.006
	(0.033)	(0.015)	(0.006)
Dad Ob/Ov WHite Girl	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
R-squared	0.057	0.073	0.044
Adjusted R-squared	0.055	0.070	0.042

Note: Robust Standard Errors in Parentheses
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 natural 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.

Table A1. Means and Standard deviation

Variable	Description	Observations	Mean	(Std. Dev)
Obese	Child Clinically measured BMI - Obese =1	14,277	0.057	-
Ovrweight	Child Clinically measured BMI – Overweight =1	14,277	0.237	-
Obboth	Parent Clinically measured BMI –Both Obese =1	14,277	0.072	-
ovboth	Parent Clinically measured BMI –Both Overweight =1	14,277	0.405	-
obmumo	Parent Clinically measured BMI –Mother Obese =1	14,277	0.144	-
ovmumo	Parent Clinically measured BMI – Mother Overweight=1	14,277	0.132	-
obdado	Parent Clinically measured BMI – Father Obese=1	14,277	0.157	-
ovdado	Parent Clinically measured BMI – Father Overweight=1	14,277	0.312	-
girl	Female Child =1	14,277	0.492	-
sch	School Aged Child=1	14,277	0.515	-
teen	Teenage Child =1	14,277	0.281	-
longill	Long Standing Illness =1	14,277	1.803	-
passm2	Passive Smoking =1	14,275	0.252	-
momft	Mother works full time	14,277	0.702	-
natmom	Natural mon=1	14,277	1	-
natdad	Natural dad=1	14,277	0.892	-
m˙menthea	Maternal mental health	14,277	1.972	0.164
f˙menthea	Paternal mental health	14,277	1.98	0.136
m˙ed	Maternal education	14,277	1.533	0.873
f˙ed	Paternal education	14,277	1.371	0.851
rural	Lives in rural area=1	14,274	0.219	-
ownflat	Owns a property=1	14,277	0.81	-
lninc	Household income (logs)	14,277	9.327	3.072
hhsize	Household size	13,604	4.336	0.901
nucfam	Nuclear family	14,277	0.112	-
time	Time	14,277	6.362	3.659
white	White ethnicity	14,270	0.79	-

Source: From waves 2000-2009 of the Health Survey for England.

Table A2: 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
Dad's effect different by age for boys?			
pre-sch	No	**0.129 (0.019)**	**0.057 (0.010)**
pre-teen	No	**0.149 (0.02)**	**0.044 (0.011)**
teen-sch	No	No	No
Dad's effect different by age for girls?			
pre-sch	No	No	No
pre-teen	No	No	No
teen-sch	No	No	No
Mum's effect different by age for boys?			
pre-sch	No	**0.17 (0.02)**	**0.070 (0.013)**
pre-teen	No	**0.19 (0.02)**	**0.081 (0.012)**
teen-sch	**0.06 (0.03)**	No	No
Mum's effect different by age for girls?			
pre-sch	No	**-0.20 (0.07)**	**-0.11 (0.03)**
pre-teen	No	**-0.23 (0.03)**	**-0.12 (0.04)**
teen-sch	**-0.01 (0.047)**	No	No
Both effect different by age for boys?			
pre-sch	**0.09 (0.05)**	No	No
pre-teen	No	No	No
teen-sch	**0.05 (0.02)**	No	No
Both effect different by age for girls?			
pre-sch	No	**0.32 (0.15)**	NO
pre-teen	0.11 (0.06)	**0.45 (0.15)**	NO
teen-sch	-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 corresponding tests of equality of coefficients in columns 3 of each panel in Table 2. Null hypotheses for each question is yes. We apply lincom in Stata 14.0 to test equality of coefficients. We report NO when the null of equality (no difference) is rejected. See notes in Table 2.