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Vertical Transmission of Overweight: Evidence From English Adoptees

Joan Costa-Font, Mireia Jofre-Bonet
Julian Le Grand

THE LONDON SCHOOL OF ECONOMICS AND POLITICAL SCIENCE

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Abstract

We examine the vertical transmission of overweight drawing upon a sample of English children, both adopted and non-adopted, and their families. Our results suggest strong evidence of an intergenerational association of overweight among adoptees, indicating transmission through cultural factors. We find that, when both adoptive parents are overweight, the likelihood of an adopted child being overweight is between 10% and 20% higher than when they are not. We also find that the cultural transmission of overweight is not aggravated by having a full-time working mother, so do not confirm the existence of a female labour market participation penalty on child overweight among adoptees. Overall, our findings, despite subject to data limitations, are robust to a battery of robustness checks, specification and sample selection corrections.

Key words: Vertical transmission, cultural transmission, overweight, children, natural parents, Body Mass Index, sample selection
JEL codes: I18, D13, Z1

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Joan Costa-Font, Associate Professor of Political Economy in the Department of Social Policy, London School of Economics and Associate of Centre for Economic Performance, London School of Economics. Mireia Jofre-Bonet, Professor in Department of Economics, City University London. Julian Le Grand, Professor in Department of Social Policy, London School of Economics.

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1. Introduction

Overweight and obesity, as a form of extreme overweight in children is of growing concern. Evidence from the Health Survey for suggests that the prevalence of overweight among 2-10 (11-15) year-olds averaged over the three years 2010 to 2012 was as high as 26% (35%), and obesity 13% (9%).[1] Nor is the situation any better in other parts of the United Kingdom (UK).[2] Even more concerning, estimates from the International Association for the Study of Obesity (IASO, 2011) indicate that the rates of overweight (including obese) children aged 5-17 years in the UK are among the highest in Europe and have experienced an increasing trend in the last decade, with a corresponding associated rising burden of morbidity (Berenson et al, 1993).

The mechanisms contributing to what might fairly be described as a *childhood overweight epidemic* are contentious, as are the appropriate policy interventions. A major problem for policy intervention is the identification of the relative importance of hereditary factors and environmental ones. Childhood obesity is found to be partly heritable in studies of identical twins, but the estimates vary from 37 to 90% (Llewellyn 2003). In adoption studies they vary from 20 to 60% (Elks et al, 2012). In contrast, overweight in children seems to be significantly more influenced by the specific individual cultural (including family) environment (Koeppen-Schomerus et al, 2001). Yet, identifying the roles of different factors is important for the purposes of any policies aimed at dealing with the epidemic. If overweight is entirely genetic, then, short of a degree of genetic manipulation that is likely to be both technically infeasible and socially unacceptable, there is little that policy can do (Manski, 2012). If, on the other hand, there is a significant cultural or environmental component in transmission, then there is room for policy intervention; but that component needs to be identified so that policy can be properly targeted.

Identifying the role of parents seems particularly important. It is possible that the spread of overweight among children can be attributed in large part to the influence of parental norms, including unhealthy role modelling. Children may consciously or unconsciously observe and model their parents especially with regards to fitness and to food consumption. Indeed, there is evidence that children's caloric intake, diet habits, level of physical activity and health behaviour in general are, at least partially, dictated by their parents' health behaviour and culturally determined social norms (Anderson and Butcher, 2006).

In this paper, we address the question concerning the existence and magnitude of parental cultural influences on children's overweight in England. We draw upon all the thirteen waves of the Health

[1] Public Health England *Child Weight Data Fact Sheet* August 1914. http://www.noo.org.uk/securefiles/141007_1330//ChildWeight_Aug2014_v2.pdf
[2] Public Health England. http://www.noo.org.uk/NOO_about_obesity/child_obesity/UK_prevalence)

Survey for England (HES) to construct a unique dataset containing children living in homes with either two biological parents or two adoptive parents. Besides the nature of the child-parent relationship, the data include information on a range of children's and parents' characteristics; on parental lifestyles; and on validated anthropometric records on children´s overweight. These data allow us to identify the magnitude of the cultural transmission of overweight and obesity by quantifying the differences in the degree of transmission from parents to children between those *children living with two biological parents* and those *living with two adoptive parents*. Our estimates control not only for children's characteristics, parents' traits and other common environmental factors, but also for sample selection bias resulting from adoption not being a random event, with some sorts of households being more likely to adopt a child than others. Additionally, we contribute to a contentious point in the literature about whether maternal full-time employment alters the transmission of overweight, even when genetic transmission is not having an effect.

Our results reveal that when both adoptive parents are *overweight*, the likelihood of an adopted child being *overweight* is between 10% and 20% higher than when they are not, a result that we attribute to *cultural/environmental transmission* of overweight. We also find that the *cultural transmission*[3] of *overweight* from parents to children is not aggravated by having a full-time working mother. Nevertheless, for natural children only, having a full-time working mother does significantly increase the positive effect of having an obese father on the likelihood of the child being overweight or obese.[4]

The remainder of the paper is organized as follows. Section 2 contains the model and outlines the empirical strategy. Section 3 describes our dataset. Section 4 reports our results. Section 5 discusses them, and Section 6 concludes.

2. **Background and Empirical Strategy**

Our empirical strategy is grounded on a health production function framework that allows the differentiation of genetic and environmental mechanisms in the intergenerational transmission of overweight. Health and non-health related traits of the parental environment influence some of the arguments in the child's production function creating links between the two generations as in Thompson (2014), who studies the intergenerational transmission of health using a CES production function model (see also Cunha et al., 2010; Cunha and Heckman 2007; and, Todd and Wolpin, 2003). In our case, we adapt the model of health vertical transmission by letting o_i indicate the overweight condition of the child i, and g_i and e_i the genetic and environmental factors influencing the weight of a

[3] Throughout the text, we refer to cultural and environmental transmission indistinguishably.
[4] Our measure of overweight includes obesity.

child, respectively, so that $o_i=A[\alpha g_i\gamma+(1-\alpha)e_i\gamma]^{1/\gamma}$. The factor g_i reflects both genes and the genetic predisposition to be overweight or obese. The factor e_i contains non-genetic influences, including socio-economic and environmental factors such as: age; gender; education; socio-economic and employment status; and urban versus rural dwelling. The intergenerational transmission stems from the fact that parents and children share with different degrees the arguments in the factors g_i and e_i. Both factors g_i and e_i will be present in the health production function of those children living with their natural parents. But, for those adopted, factors in g_i will be null. As Thompson (2014) illustrates for health, in our setting when $\gamma=1$ genes and environment have an additively separable influence on overweight status of the child and α and $1-\alpha$ represent the relative weight that e_i and g_i have, respectively, in the likelihood of a child being overweight.. When $\gamma\leq 1$, there is no separability between genes and environment and they interact in the production of health.

In our setting, we assume that being overweight has both genetic and environmental (or cultural) causes and that, as for other conditions, the specific interaction of genes and environmental factors will be crucial in determining whether a child is overweight . For instance, a predisposition of the parents to gain weight arguably may make them more aware of the nutritional content of food or of the need to do exercise, and this may translate in their children being exposed to healthier foods and more exercise, and ultimately less likely to be overweight..

As we explain below, we present estimates of different econometric specifications that compare the transmission of overweight across biological and adopted children. The results of the estimation for non-biological children should remove the shared genetic components of transmission in e_i. But, as pointed by Thompson (2014), since we are not able to identify the gene-environment interactions, the resulting estimates for adoptees represent the average of α over the support of e. Moreover, since assignment to a given type of household (both biological parents; only one biological parent; and both adoptive parents) is not random, correcting for observable and unobservable sample biases will be crucial to identify non-genetic transmission of overweight. We correct for these biases both by using a Heckman selection model and by propensity score matching design.

Our empirical strategy exploits the health production function above. We specify a linear model 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, indicator variables taking value 1 if both parents being overweight; only the mother being overweight; or only the father being overweight, respectively:

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

where o_{ij}^{*} indicates the latent overweight of child *i* in household *j*; o_{ij}^{b} is an indicator variable for *both parents* of child *i* in household *j* being overweight or obese; o_{ij}^{M} takes value one if *only the mother* of child *i* in household *j* is overweight ; o_{ij}^{F} takes value one if *only the father* of child *i* in household *j* is overweight ; Z_j is a vector with the parents' characteristics and X_{ij} a vector of the child's characteristics; 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 ($o_{ij} = 1$) is the probability that the corresponding latent variable is positive, i.e. :

$$P(o_{ij} = 1) = P(o_{ij}^{*} > 0) = \mathbf{\Phi}(\delta_0 + \delta_b o_{ij}^{b} + \delta_M o_{ij}^{M} + \delta_F o_{ij}^{F} + \beta Z_j + \theta X_{ij}) \qquad (2)$$

Therefore, in this framework, coefficients δ_b, δ_M, and δ_F will estimate the effect of *both parents*, *only the mother* or *only the father* being overweight on the likelihood a child being overweight , respectively.

We estimate equation (2) for two different groups of children: those who live with both biological parents and those who live with both adoptive parents. The difference between the coefficients for children that are biological (exposed to both genetic and environmental transmission of overweight and those that are adopted (only to the environmental transmission), will give us a measure of the relative importance of environmental intergenerational transmission for overweight.

We first estimate equation (2) using a Probit model, without taking into account the selection bias of children into each of these groups. Second, we estimate equation (2) controlling for the sample bias of being in an adoptive family by using both a Heckman selection or Heckit model and a propensity score matching-based correction. The *exclusion restriction* for the identification of the Heckit models relies on the parents' age and the father being unemployed, which appear to affect the likelihood of an individual being adopted but not the overweight of the child. The propensity matching score corrects the effects of sample selection (as in Rosenbaum and Rubin, 1983) by allowing estimating the conditional probability of each child being in an adoptive household given observed covariates of the child and the household. The propensity score is then used as a covariate to adjust the original model. As a robustness check, we also estimate equation a variation of equation (2) using Ordinary Least Squares.

Additionally, we estimate equation (2) allowing the mother working full time to influence the degree of transmission of overweight from parents to children. We do so by interacting the indicator variable taking value 1 when the mother works full time with the overweight indicator variables for the parents.[5]

We have considered additional specifications including the specific transmission of mother-daughter and father-son; and whether the transmission has evolved with each wave of the survey, i.e. over time. We do not include these results as sample limitations hampered the robustness of the coefficients.

3. Data

The dataset we use to estimate the models above originates in the Health Survey for England (HSE). In particular, the dataset results from merging information contained in thirteen different waves of the HSE, from 1997 to 2009. The HSE is an annual survey designed to measure health and health-related behaviours, including weight and height, body mass index (BMI), fruit and vegetable consumption, alcohol consumption and smoking in adults and children living in private households in England. The survey also contains the socio-economic status of the household and core information on all its members, including their relationship. This allows us to categorize children in types of households depending on whether they live with both their biological parents or they live with a set of parents neither of whom is biological.

Adoption in the UK can be legally carried out by parents that are over 21 years of age that has at least one year of residency and have a fixed permanent home in the UK irrespective of the civil status. The latter includes the possibility of the partner of the natural parent to being considered 'adopter parent' too (UK Government, 2013)[6]. The process take place after an application to an adoption agency whether a council or a privately run one. The conditions to be met to be regarded as suitable include a *full medical examination*, a police check of no pre-existing convictions, including three-reference letters, training and an assessment by a social worker. Recommendations regarding suitability of an adopter parent are made by an external 'adoption panel'. Once an adoption panel makes decisions, then the parents are matched with a child locally or referred to the Adoption Registry.

Because of the nature of our dataset, we are confronted with several limitations. First, we do not have information on the biological parents of the adopted children. Thus we cannot control for early nutrition effects they may have faced and we cannot observe the weight of the biological parents. Second, we cannot identify the exact time of adoption, and can only indirectly control for it through

[5] We also estimated the model using families in which one of the parents is biological and the other is not but given that the baseline characteristics of this type of households are markedly significantly different from the natural and adoptive parents' families, we do not present it in here.
[6] https://www.gov.uk/child-adoption

age. Third, we cannot identify whether if the individuals were born overseas although we do have their ethnicity information.

More generally, studies using data from adoptees face challenges that complicate the identification strategy (Holmlund et al, 2011). Parental sorting is not random. "[A]doption agencies often place infants selectively by matching natural and adoptive parent characteristics, such as education, occupation, and impressions about intelligence" (Scarr and Weinberg, 1994). Thus, if the genetic influence of the biological parents is not accounted for, statistical associations between the outcomes of adopted children and their adoptive parents could reflect a combination of the adoptive parents' environmental influences and the correlated genetic inheritance. A way to partially address this is to correct for sample selection into adoptive families using the characteristics of the child and the foster parents. Using this approach, Bjorklund *et al* (2004) find no evidence of the existence of a sample selection bias as estimates between adoptees and biological parents in Sweden; Sacerdote (2007) uses a sample of American Korean adoptees quasi-randomly assigned to adoptive families and finds evidence of cultural transmission of some health behaviours. In our case, robustness checks and subsample analysis can help ensure that the subsample of adoptees compares to the rest of the population.

In this paper, we limit the source of disparity between our sample of biological and adoptive families by restricting our analysis to two-parent households. We also use children's and parents' observable characteristics to correct for sample selection biases exploiting two-stage Heckit models and Propensity Score Matching (PSM) based ones.

Our final dataset contains children of all waves, including their socio-demographic characteristics, their physical measurements (BMI, weight, height, etc.), those of their parents and the nature of their relationship. The measurements of height and weight in the HSE are validated by a nurse, thus overcoming the problem of measurement error of these values present in other surveys containing children, i.e. Phipps et al. (2004) or Anderson et al. (2004).

Table 1 provides our sample descriptive statistics including the rates of overweight and obesity for children and their parents. We report the statistics for the overall sample (13,836 observations), and disaggregated by type of household, i.e. those in which both parents are biological (13,536 observations) and those in which both parents are adoptive (300 observations). In the last column we show the outcome of the T-Tests analysing if the means of the two groups are significantly different.

Looking at these statistics and the results of the T-tests, we observe that only for nine out of forty-eight variables is the difference between the groups statistically different at the 99% level and for five variables the difference is significant at the 90% level. In the light of this, we are confident that the baseline characteristics of our biological and adopted household are not challengingly different. We do observe nevertheless that adopted children in the sample are slightly older than those in a biological parents' household; they are slightly more likely to have an obese mother, an obese father, or both parents obese; their parents tend to answer the education question less often and when they do, they are less likely to be in the lower end of the education distribution. Their mothers choose the 'other' occupation category more often; their parents are slightly older; they live less often in suburban areas; and, they are more often exposed to passive smoking.

The percentage of overweight children is about 23% (slightly higher for adopted but not statistically significant); of obese children 5.6%; of both parents being obese, 7% for the biological parents' households and 10% for the adoptive; of both being overweight ,about 40% for the former type of household and 47% for the latter. Only the mother being obese happens in about 16% of our sample; only the father being obese in 15% of the first type of households and in 17% of the second type (but again the difference is not statistically significant); only the mother being overweight in about 13% of the biological parents' families and in 11% of the adoptive families. Lastly, only the father is overweight in about 30% of both types of households. These univariate differences in the percentage of obese and overweight parents could be due to the slightly higher age of adoptive parents. We refer to the table for further details on the exact figures for the forty-eight variables. Finally, it should be noted that unlike BMI in adults, BMI among children changes over time and hence fixed thresholds can provide misleading findings. Hence, for the children we use the international standard BMI cut off points for age and sex published by the International Obesity Task Force (IOTF) as in Saxena et al. (2004). For parents, we used the standard overweight and obesity BMI cut-offs: parents are classified as overweight if their BMI is between 25 and 30 and as obese if it is greater than 30.

4. Results

Results are presented in Tables 2, 3 and 4. Table 2 shows the estimates of the transmission of the both parents being overweight on the likelihood of the child being overweight. The dependent variable is indicated in the top row and whether the parents are overweight is indicated in the second row. The third row in this table indicates which type of household the child is living in (both parents biological or both parents adoptive). The method used to estimate these coefficients is a probit model and expressed as marginal effects. Table 3 re-estimates the coefficients in Table 2 by correcting the sample selection potential biases of belonging to each type of household using Heckit models and propensity score matching models. Finally, Table 4 is an extension of all preceding tables in which the effect of the parents' weight on that of their children is estimated controlling for the fact that the mother works full time.

The results in the first two columns of Table 2 indicate that the transmission *overweight from parents to children* is significant and positive when both parents are overweight for both groups of families. The increase of the likelihood of being overweight of those children when both parents are biological is 0.270, and for those adopted 0.210. Given that the biological-parents coefficient is picking up both genetic and cultural transmission, whereas the adopted-parents coefficient only reflects cultural transmission, this suggests that the relative importance of the cultural transmission when both parents are overweight is big. *Only the mother being overweight* increases significantly the likelihood of the offspring being overweight by 12% only for children living with both biological parents, but not for the adopted group. *Only the father being overweight* is significant both for families where both parents are biological (0.116) and for those where they are adoptive (0.240). The difference between these two coefficients suggests that, when only the father is overweight, the *cultural transmission* for adopted children is more important than both the genetic and cultural transmission for natural children.

In the second panel we report the estimates of the effect of the *parents being obese* on the probability of the *children being overweight*. For those with both biological parents, *both parents being obese* increases the likelihood of the children being overweight by 0.342; *only the mother being obese* by 0.176; and *only the father being obese* increases it by 0.144. For those families in which both parents are adoptive, the only significant coefficient is that of *both parents being obese* and its effect on the probability of the child being overweight is 0.216. The cultural intergenerational transmission of obese parents to overweight children thus seems a bit weaker than of overweight parents to overweight children, but still very sizeable.

Finally, the third panel in Table 2 looks at the relationship between the *obesity of the parents* on the probability of the *children being obese*. For this case, for the first type of families (both biological), if *both natural parents are obese*, the likelihood of the *child being obese* as well increases by 0.170, when *only the mother is obese,* it increases by 0.070 and when *only the father is obese* by 0.044. For the adoptive families, if *both parents are obese*, the likelihood of the child being obese goes up by 0.208 but the effects of the *only the mother* or *only the father* being obese are not significant probably due to the small sample size. So again there appears to be cultural transmission of obesity, but by a smaller proportion than overweight.

Table 3 corrects the estimates in Table 2 by sample selection using two-stage Heckit and PSM-based models.[7] Results in Table 3 are quite similar to those in Table 2 but a few remarks are to be made: First, in the Table 3, the estimates of the effects of *both parents being overweight* on the likelihood of the *child being overweight* are higher than when not correcting for sample selection for those households where both parents are adoptive (above 0.246 instead of 0.210), and slightly smaller for those living with their biological parents (0.252 instead of 0.270). The effect of *only the mother being overweight* and *only the father being overweight* become significant for adopted children when using the PSM-based correction for sample selection (0.154 and 0.106, respectively); using the Heckit correction *only the father being overweight* is significant and higher than in Table 2 (0.272 instead of 0.240).

Second, in the second panel corresponding to the influence of *obese parents* on the *child being overweight*, we observe that the sample selection correction increases all coefficients for the biological parents' households and also for adoptive children if the PSM-based approach is applied, but not for the Heckit correction approach. Also, the PSM-based estimates coefficients of *only the mother* or *only the father being obese* for adoptive children become significant and similar to those of the biological parents households (0.166 and 0.139, respectively). The Heckit model estimates of these indicator variables remain insignificant.

Third, by looking at the third panel, we observe that sample selection correction by either approach reduces slightly the effect of the *transmission of obesity from parents to children* for children living with their biological parents. Using the Heckit correction model reduces greatly the effect of both adoptive parents being obese on the probability of the adoptee being obese (0.027). The sample selection correction using the PSM-approach increases the effect of *both parents being obese* (to 0.181) and *only the mother being obese* or *only the father being obese* are significant and positive (0.082 and 0.051, respectively).

Finally, the fact that the PSM-scores interacted with our variables of interest are not significantly different than zero could indicate that the sample selection issues in our sample are not excessively worrying, which is in accordance with the baseline characteristics of our two samples being quite similar. Thus, the biases in the coefficients reported in Table 3 should not be too important.

[7] The selection equation in the Heckit model includes parental age and the father being unemployed. The PSM scores use gender of the child, whether the mother works full time, the father being unemployed, household size, and whether the household lives in an urban setting.

The results in Table 4 also test whether the fact that the mother works full time has an impact on the overweight transmission estimates. To do so, we estimate the specifications in Table 2 allowing for an interaction of an indicator variable of the mother working full time with the overweight/obesity status of the parents. As can be observed from the table, none of the interactions are significant except for that with the *obesity status of the father only* in the second and third panel and only for the biological parents' kind of families. Thus, when *only the father* is obese and at the same time the *mother works full time* the likelihoods of both the child being overweight (0.047) and being obese (0.020) increases significantly beyond the sole effect of the father being obese. But, probably due to sample size issues arising from the interaction terms, some of the coefficients that were significant in previous specifications for adopted children are insignificant when using this specification.

5. Discussion

Overweight is an expression of both genetic and cultural influences. In this paper we have attempted to estimate the cultural transmission of overweight. We contribute to the literature of intergenerational transmission of health, by quantifying the strength of the intergenerational correlation of overweight in both natural children and adoptees. The analysis is conducted making use of a uniquely constructed dataset of English adoptees from 1997 to 2010. We have examined intergenerational transmission alongside a long list of other confounding variables that could be driving the association such as education, parental and child age, gender effect and, following the literature, the effect of female labour market participation.

We base our empirical approach on a theoretical model of health production by which children's overweight depends on the overweight or obese status of their parents, and thus implicitly on the parents' lifestyle choices and net caloric intakes. We follow an empirical strategy that has taken selection issues in consideration alongside drawing upon a naïve probit model. We estimate our empirical models of overweight for two types of children, those living with both their natural parents and those living with adoptive parents. We use various specifications, which include the observable characteristics of the child, the parents and the household.

Our results indicate quite strongly that there seems to be a powerful cultural transmission of overweight inter-generationally, in addition to that resulting from the genetic links. For obesity, the results are less strong, but both parents being obese or the father alone being obese, increase the probability of observing an overweight and/or an obese child even when they are not genetically related. However, the mother alone being obese is an insignificant factor.

These findings are robust to different specifications, including the mother working full time and income, which has been pointed out as the culprit for child's obesity (Anderson, 2003). We do not find evidence that the mother works full time explains children's obesity, nor their tendency to be overweight. We control for education of both parents, type of dwelling, various characteristics of the household, and degree of urbanisation. Our findings survive the inclusion and exclusion of these controls.

There is an intriguing aspect to these results. In general, the results concerning the powerful cultural transmission effect are much stronger for overweight than obesity. If both adoptive parents are overweight, or if only the father is overweight, this increases the probability of the children being overweight by about 25% to 30%. However, if both adoptive parents are obese, when we control for the mother working full time this has no significant effect on children's obesity. This suggests that the primary mechanism of the intergenerational transmission of obesity is much more likely to be genetic than that for overweight. Indeed, we can find little evidence from our results of any important cultural transmission of obesity.

The importance of the cultural transmission of overweight may be emphasized by the fact that in some of the specifications, when correcting the sample selection bias of adoptive children using the PSM approach, *both adoptive parents being overweight* has a larger impact on the probability of their children being overweight than when *both biological parents are overweight*. This would suggest that natural parents would have a far smaller cultural impact on their children being overweight than adoptive parents do. The latter can be the result of their being more likely to follow a different lifestyle pathway unrelated to biological triggers of behaviour.

Another thought-provoking feature of the results concerns a difference in the impact of the non-natural mother's and father's overweight. In some of the specifications the mother's overweight is not significant while the father's is. A possible explanation is that the mother is in charge of the nutrition of the children and their father and may tend to overfeed them while underfeeding or feeding adequately herself.

6. Conclusion

This paper has drawn upon a uniquely constructed dataset of English adoptees to investigate the existence and mechanisms of intergeneration transmission of overweight. We have found that that children's overweight is robustly related to the overweight of the parents, even when there is not genetic transmission as is the case of adoptees. However, while we can establish there is a strong cultural transmission of overweight, our evidence is weaker for obesity.

We also find that the *cultural transmission* of *overweight* or *obesity* from parents to children is not aggravated by having a full-time working mother. Nevertheless, for natural children only, having a full-time working mother does significantly increase the positive effect of having an obese father on the likelihood of the child being overweight or obese.

We acknowledge that our estimates are subject to several limitations imposed by the nature of the data. First, adopted children might belong to a healthier/unhealthier sample than the biological, although a wealth of studies suggest that selective placement of adoptees does not seem to have an impact on the cultural transmission of health (Wilcox-Gok, 1983) and thus on health itself. Second, although adopted children are not genetically related to their parents, adoption agencies do attempt to match biological and adoptive parents in various ways (selective placements), a factor that could cause additional sources of sample selection.[8] Third, we cannot observe the age of adoption (though the majority of adoptions takes place before the age of 3) and, hence, we cannot control for the length of a child's exposure to his/her adoptive family environment. Fourth, unlike the data obtained from adoption registers, we do not have information on the biological parents of the adoptees, and whether the children were foreign born or not. To address some of the non-randomness issues, we have compared the two types of households to ensure they are not significantly too different and still correct for sample selection biases using two-stage Heckman models and Propensity Score Matching (PSM) adjustments. We have also run robustness checks using different specifications. Finally, the sample of obese adopted children is small, and the number of those who have obese parents even smaller. This hinders the strength of our results regarding the cultural transmission of obesity from parents to children.

Our paper improves upon existing literature by using the Health Survey for England to examine a sample of children living in homes where parents are either both adoptive or both biological. The advantage of this dataset is that it contains the same data on adopted and biological children and their living-in parents, including anthropometric measurements and parents', children's and household's characteristics. Thus, unlike data on adoptees from administrative records, we do not need to match the sample of children with the general population.

A comparison of our findings with that of the wider literature on intergeneration transmission for education (Holmlund et al, 2011) reveals that for obesity genes play a larger role than for overweight,

[8] To address this issue some studies use information on the adoptees' biological parents (Björklund et al, 2006), and Sacerdote (2006) draws upon a random assignment of children.

which is quite sensitive to changes in the environment. This is consistent with health conditions such as asthma, allergies, headaches and diabetes (Thomson, 2014) and other studies that do not disentangle total from cultural transmission (Classen and Hokayem 2005, Classen, 2010 and Costa-Font and Gil, 2013).

We conclude that this paper provides evidence in favour of the hypothesis that there is a strong cultural component in the transmission of cultural habits that promote overweight from parents to children. That is, gender specific effects might still reflect that, as some studies show (Lake et al., 2006), food responsibility was predominately a female dominated, but the ingest of such food might be more that proportionally consumed by men and children. The importance of *both* parents being overweight in explaining the overweight of the children might as well reflect evidence of assortative mating, or alternatively a reinforcing environmental effect that takes place when both parents adopt similar behaviours. One hypothesis consistent with assortative mating is that health and lifestyle preferences end up determining partner-matching. Thus, both parents may be overweight or obese as a result of sharing a common lifestyle and tastes, which are in turn passed on to their children.

Our results suggest that that there is room to design policies to tackle children's overweight and obesity by influencing parental overweight and their lifestyles, and that ideally both parents should be influenced for the effect to be more effective; otherwise problems of children overweight are likely to persist. Overweight is passed through generations, and the pathway seems to be primarily driven by the children environment. In contrast, and consistently with the behavioural generics literature, obesity exhibits a highly genetic component.

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Table 1: Summary Statistics and test of differences in means

			A	B	
		Overall Sample	**Natural**	**Adopted**	**Sign Diff B-A**
	Number of Observations	13836	13536	300	
Child overweight and other characteristics	Obese Child	5.7%	5.7%	5.7%	
	Overweight Child	23.5%	23.5%	25.3%	
	Age of Child	9.1	9.0	10.9	***
	Female	49.1%	49.2%	46.3%	
	White	78.7%	78.6%	79.3%	
	Black (Caribbean, African or Other)	4.4%	4.4%	5.0%	
	South East Asian and Other	12.7%	12.7%	15.0%	
	Pakistan/Bangladesh/Chinese	4.2%	4.3%	0.7%	
Parents' obesity	Obese Mother	21.1%	21.0%	26.0%	*
	Obese Father	22.4%	22.3%	27.3%	*
	Overweight Mother	13.0%	13.0%	11.3%	
	Overweight Father	31.7%	31.7%	29.3%	
	Both parents Obese	7.0%	6.9%	10.0%	*
	Only Mother Obese	14.1%	14.1%	16.0%	
	Only Father Obese	15.4%	15.4%	17.3%	
	Both parents Overweight	39.9%	39.7%	46.7%	*
	Only Mother overweight	13.0%	13.0%	11.3%	
	Only Father Overweight	31.7%	31.7%	29.3%	
Parents' characteristics	Mum Education: NA	13.1%	13.1%	15.3%	
	Mum Education: HE	31.2%	31.2%	32.3%	
	Mum Education: A/O Level	47.8%	47.8%	45.7%	
	Mum Education: CSE	5.9%	5.9%	5.3%	
	Mum Education Foreign	2.0%	2.0%	1.3%	
	Dad Education: NA	15.0%	14.8%	20.3%	***
	Dad Education: HE	41.3%	41.5%	32.7%	***
	Dad Education: A/O Level	37.2%	37.1%	39.0%	
	Dad Education: CSE	5.4%	5.4%	5.7%	
	Dad Education Foreign	1.1%	1.1%	2.3%	
	Mother at home	26.1%	26.2%	23.7%	
	Mother Employed	69.8%	69.8%	68.3%	
	Mother Retired	0.1%	0.1%	0.0%	
	Mother Other	4.1%	4.0%	8.0%	***
	Dad at home	1.3%	1.3%	2.0%	
	Dad Employed	90.4%	90.4%	88.3%	
	Dad Retired	0.7%	0.7%	1.7%	
	Dad Other	7.6%	7.6%	8.0%	
	Mother's Age	38.3	38.3	41.1	***
	Father's Age	41.0	40.9	43.8	***
Other Household	Income	£30,899.11	£30,913.34	£30,257.37	

characteristics	Own Flat	82.7%	82.7%	84.0%	
	Small Family	44%	45%	13%	
	Large Family	28%	27.6%	43.3%	***
	Large Adult Family	12%	12.3%	18.7%	***
	Urban	11%	11%	24%	
	Suburban	44%	44.5%	38.0%	*
	Rural	22%	22.0%	24.0%	
	Passive Smoking in household	22.9%	22.7%	31.3%	***

Notes: This table provides the summary statistics of the variables used in our. Column one displays the statistics for the overall sample, column two for households in which both parents are natural, column three for families with adoptive parents, and, finally, column four indicates the level of significance of the difference in means between households with natural parents and those with adoptive parents. The vertical panels shows first variables reflecting the characteristics of the child including overweight; second the parental overweight; third parental characteristics; and finally, other household characteristics. The level of significance of the t-test are indicated by the number of stars: * p<0.05 ** p<0.0*** p<0.001.

Table 2: Probit Model of the influence of parents being overweight on the likelihood of child being overweight

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variable:	Overweight		Overweight		Obese	
Control for parents being:	Overweight		Obese		Obese	
Type of Household	Both parents natural	Both parents adoptive	Both parents natural	Both parents adoptive	Both parents natural	Both parents adoptive
Both	0.270***	0.210**	0.342***	0.216*	0.170***	0.208**
	(0.014)	(0.086)	(0.019)	(0.129)	(0.016)	(0.100)
Mum Only	0.129***	0.102	0.176***	-0.007	0.070***	-
	(0.019)	(0.124)	(0.013)	(0.068)	(0.009)	-
Dad Only	0.116***	0.240**	0.144***	0.011	0.044***	0.025
	(0.015)	(0.104)	(0.013)	(0.068)	(0.007)	(0.026)
Girl	0.047***	0.036	0.048***	0.046	0.016***	0.003
	(0.007)	(0.047)	(0.007)	(0.051)	(0.004)	(0.010)
Observations	15534	15536	15534	15536	15534	15536
Log Likelihood	-6995.728	-157.207	-6995.551	-158.557	-2761.131	-48.932

Notes: This table reports the estimates of the probit models estimating the effect of measures of parental overweight on the likelihood of a child being overweight based on BMI. The rows identify the effect of both parents being overweight, only the mum being overweight or only the father being overweight. Given that gender might exert a specific effect, we include the effect of the child being a girl. The first column shows the effect of parental overweight on likelihood of the child being overweight when both parents are natural. The second column estimates the same for the sample of households when both parents are adoptive. In the third and fourth columns, we examine the effect for both household samples of parental obesity on child overweight. Finally, the last two columns estimate the effect of parental obesity on child obesity. Due to the reduced sample size, the last column does not produce estimates for the mother being obese. All estimates are marginal effects. The models control also for ethnicity, parents' education, passive smoking, flat ownership, and income. We provide robust standard errors in brackets.

Table 3: Models of the influence of parents overweight on child overweight correcting from sample selection bias of type of household

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
Dependent variable:	Overweight			Overweight			Obese		
Control for parents being:	Overweight			Obese			Obese		
Type of Household	Both parents biological	Both parents Adoptive		Both parents biological	Both parents Adoptive		Both parents biological	Both parents Adoptive	
Model:	Heckprobit		PSM - correction	Heckprobit		PSM - correction	Heckprobit		PSM - correction
Both	0.252***	0.246**	0.287***	0.277***	0.148**	0.377***	0.102***	0.027***	0.181***
	(0.015)	(0.086)	(0.031)	(0.016)	(0.119)	(0.042)	(0.011)	(0.123)	(0.038)
PSM interaction with Both			-0.781			-1.354			-0.171
			(1.244)			(1.360)			(0.547)
Mother	0.115***	0.157	0.154***	0.154***	-0.014	0.166***	0.058***	-0.188	0.082***
	(0.016)	(0.129)	(0.044)	(0.011)	(0.063)	(0.031)	(0.008)	(0.811)	(0.022)
PSM interaction with Only Mother			-0.935			0.222			-0.359
			(1.526)			(1.043)			(0.481)
Father	0.109***	0.272***	0.106***	0.129***	-0.001	0.139***	0.039***	0.008	0.051***
	(0.014)	(0.100)	(0.033)	(0.011)	(0.061)	(0.029)	(0.007)	(0.039)	(0.018)
PSM interaction with Only Father			0.507			0.077			-0.221
			(1.300)			(1.021)			(0.495)
Girl	0.046***	0.046	0.046***	0.047***	0.038	0.048***	0.017***	0.002	0.015***
	(0.007)	(0.057)	(0.007)	(0.007)	(0.055)	(0.007)	(0.004)	(0.012)	(0.004)
Observations	15534	15536	13826	15534	15536	13826	15534	15536	13826
Log Likelihood	-1.27e+04	-1574.124	-7166.998	-1.27e+04	-1575.787	-7170.681	-8451.805	-1456.645	-2823.569

Notes: In this table we report the estimates of the effect of parental overweight on the likelihood of a child being overweight (based on BMI) controlling for sample selection bias using two approaches, a Heckit and a Propensity Score Matching (PSM) specifications. As in Table 2, rows identify the both parents being overweight, only the mum being overweight or only the father being overweight. The coefficients in the additional row below each of these regressors reproduce the estimates of the interaction of the PSM indicator variable with both parents, only the mother or only the father being overweight. Again, we include the effect of the child being a girl. The first column shows the effect of parental overweight on likelihood of the child being overweight when both parents are natural. The second and third columns show the estimates for the sample of households when both parents are adoptive: Column two contains the marginal effects of the Heckit model and column three those correcting using the PSM specification. The fourth, fifth and sixth columns present the effect for both household samples of parental obesity on child overweight. The last three columns estimate the effect of parental obesity on child obesity. All estimates are marginal effects. The models control also for ethnicity, parents' education, passive smoking, flat ownership, and income. In the Heckit selection equation, we include parents' age, the father being unemployed or working full-time, mother's qualifications, type of household, and living in an urban area. Propensity score to be adopted based on gender of the child, mother working full-time, father being unemployed, household size, urban setting. We provide robust standard errors in brackets.

Table 4: Probit Models controlling for mother working full time

	(1)	(2)	(3)	(4)	(5)	(6)
Dependent variables:	Overweight		Overweight		Obese	
Control for parents being:	Overweight		Obese		Obese	
Type of Household	Both parents natural	Both parents adoptive	Both parents natural	Both parents adoptive	Both parents natural	Both parents adoptive
Both	0.273***	0.212***	0.325***	0.240*	0.150***	0.124
	(0.017)	(0.064)	(0.032)	(0.140)	(0.025)	(0.101)
Both*(mother work FT=1)	-0.005	-0.003	0.019	-0.030	0.012	0.036
	(0.013)	(0.073)	(0.031)	(0.128)	(0.013)	(0.061)
Mother	0.116***	0.047	0.194***	-0.087	0.065***	
	(0.026)	(0.154)	(0.021)	(0.129)	(0.013)	
Mother (mother work FT=1)	0.017	0.082	-0.022	0.121	0.004	
	(0.024)	(0.177)	(0.019)	(0.211)	(0.010)	
Dad	0.124***	0.241**	0.106***	-0.029	0.026**	0.009
	(0.019)	(0.107)	(0.022)	(0.084)	(0.011)	(0.029)
Dad*(mother work FT=1)	-0.011	-0.001	0.047**	0.071	0.020*	0.020
	(0.016)	(0.087)	(0.023)	(0.136)	(0.012)	(0.049)
Female	0.047***	0.035	0.048***	0.047	0.016***	0.004
	(0.007)	(0.045)	(0.007)	(0.047)	(0.004)	(0.010)
Observations	13528	300	13528	300	13528	238
Log Likelihood	-6995.026	-157.080	-6991.820	-158.157	-2758.701	-48.441

Notes: This table reports the estimates of the probit models estimating the effect of measures of parental overweight on the likelihood of a child being overweight (based on BMI) examining if the mother working full time compounds the effect of parental overweight. The rows identify the effect of both parents being overweight, only the mum being overweight or only the father being overweight. The extra rows below each of these indicators include interactions with the mother working full time. As in Table 2, the first column shows the effect of parental overweight on likelihood of the child being overweight when both parents are natural. The second column estimates the same for the sample of households when both parents are adoptive. In the third and fourth columns, we examine the effect for both household samples of parental obesity on child overweight. Finally, the last two columns estimate the effect of parental obesity on child obesity. Due to the reduced sample size, the last column does not produce estimates for the mother being obese. All estimates are marginal effects. The models control also for ethnicity, parents' education, passive smoking, flat ownership, and income. We provide robust standard errors in brackets.

Appendices:

Appendix A1: Alternative measures of parental obesity

For the parents, we also construct measures of obesity (or of increased health risks due to being overweight) based on the Waist to Hip (WHIP) ratio, and on the waist circumference. For WHIP, we use the classification suggested by the WHO report on obesity and risk of diabetes (1999) by which men are considered obese if their WHIP exceeds 0.95, and women are obese if it exceeds 0.8. With respect to the waist circumference, we follow the National Institute for Health and Clinical Excellence (NICE) Guidelines by which the risk of health problems for men are increased if their waist is above or equal to 94cm and for women if above 80cm (Townsend et al, 2009). These two additional measures of obesity/increased risk of health problems due to excessive weight are used in our robustness checks. For children, the non-BMI-based alternative measures are not feasible as only 13.5% of all children in our sample have valid measures for waist and waist to hip ratios and an insignificant number of those not living with both their natural parents.

The simple probit models that use different measures of obesity show that the coefficient for both parents' being obese is not significant; that of the mother being obese is positive and significant for both measures (0.231 and 0.483, respectively); and that of the dad being obese is also significant and positive for the first measure WHIP. For the adopted children, the coefficients are not significant. We interpret this lack of results based on alternative measures as not surprising given that we are using different measures of obesity for children and their parents.

Appendix A2: Models with one biological parent - Mixed families

For mixed families, the effect of both parents being overweight or obese are positive and significant in all specifications, including the last three in which we control for the mother working full-time. The coefficient associated to only the mother being obese on the likelihood of the child being overweight is also always significant and positive. That only the dad is obese or overweight does not have a significant positive effect on the likelihood of the child being obese or overweight except for the PSM-based estimates. The latter is possibly due to the fact that mixed families tend to have natural mothers and non-biological dads. When we control for the mother working full-time by interacting it with the overweight and obesity measures of the parents, the only remarkable effect is that it decreases slightly the transmission of obesity from both parents to children (column 12, coefficient -0.038).

Appendix A3: Correlation of parental and children's BMIs using OLS and Quantile Regression

The effect of the BMI of the mother on the BMI child is about 0.151 when both parents are natural and about 0.139 when they are mixed. The effect is not significant for the adopted group, possibly because of sample size issues. The effect of the father's BMI on the child's BMI is again significant and positive for natural parents' families and mixed (0.161 for the first group and 0.082 for the mixed one).

The quantile regression estimates for the 75% percentile for the BMI shows that for the upper tail of the BMI distribution, these effects are only strengthened, the effects of the mother's BMI are 0.213 and

0.180 for the both natural parents' and mixed families, respectively. The effect of the father's BMI is 0.223 and 0.082 for natural and mixed families, respectively. Being a female has a very large and significant impact on these two types of families too, being the coefficient 0.0389 and 0.569 for the general OLS specification but jumping to 0.611 and 0.807 respectively for the BMI upper 75% percentile.

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The Centre for Economic Performance Publications Unit
Tel 020 7955 7673 Fax 020 7404 0612
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