Vertical Transmission of Overweight: Evidence from a sample of English Adoptees

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Abstract

We examine the vertical transmission of overweight drawing upon a fifteen year sample of English adults and their children, both adopted and biological, for which we can retrieve clinical measures height and weight. We find that, when both parents are overweight, children exhibit an increased likelihood of overweight, irrespective of whether they are adopted or biological children. When both parents are obese as opposed to overweight the picture is different. We find that the likelihood of child overweight increases by 16.7 percentage points among natural (non-adopted) children but only by 4.5 percentage points among adopted children. This suggests that the transmission of overweight when both parents are obese is not merely genetic, and what has been called *vertical or parental* transmission plays a non-negligible role. Our findings are robust to a battery of robustness checks.

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1 Introduction

Overweight in children is a growing concern in a number of European countries. Evidence from the Health Survey for England suggests that the prevalence of overweight among 2-10 (11-15) year-olds over the three years 2010 to 2012 was as high as 26% (35%), and obesity 13% (9%).[1] The picture is not 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 obesity) among 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). This paper will contribute to offer an explanation for such a phenomenon.

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, Costa-Font and Gil, 2013). Although we do not attempt to provide a comprehensive review of the growing literature on transmission of obesity, recent estimates using adoptees 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). Identifying the underlying roles of different contributing factors to child obesity important for policy design. This is especially the case given that the epidemic exerts significant consequences on the development of chronic con-

[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. `https://www.noo.org.uk/NOO_about_obesity/child_obesity/UK_prevalence`.

ditions (Costa-Font and Gil, 2005). 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 only a limited set of policy options available to prevent it (Manski, 2012). If, on the other hand, there is a significant cultural or environmental component in transmission, then there is room for preventative policy intervention; but that component needs to be identified so that policy can be properly targeted.

Identifying the role of parents play in the development of overweight 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 modeling (Costa-Font and Jofre-Bonet, 2020). 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 examine the vertical (parental) cultural influence on (transmission of) children's overweight. Our paper contributes to the existing literature by shedding some light on the question of inter-generational transmission of overweight in England. Family studies using twins and adopted children tend to find that BMI similarities are largely related to genes but the evidence is not not conclusive and has been more focused on obesity and BMI than overweight. Although Sacerdote (2007) finds little evidence that obesity is transmitted from parents to adopted children using a quasi-random design of Korean adoptees in the US, a concern with this particular study is that Koreans' rates of obesity and overweight are among the lowest of the world (OECD, 2015). More generally, other studies have found that the associations between adoptive parents and children BMI is small or insignificant. Stunkard et al.(1986) and Sorensen and Stunkard (1993) had found that adults adopted at birth do not share obesity or overweight with

their adoptive siblings or parents. In contrast, Koeppen-Schomerus et al. (2001) uses a twin study and provides evidence that overweight is substantially influenced by the family environment and Price and Swigert (2012) find a large variation in siblings' BMI, which questions its heritability.

We exploit data from thirteen waves of the Health Survey for England (HSE) to construct a unique data-set containing children living in homes with either two biological parents, or two adoptive parents. Besides the nature of the child-parent relationship, the data includes information on a range of children and parents characteristics; parental lifestyles; alongside validated anthropocentric records on children´s overweight. These data allow us to identify the magnitude of the cultural transmission of overweight 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 strictly[3] adoptive parents. Our estimates control not only for children's characteristics, parents' traits and other common environmental factors, but also for potential selection bias resulting from adoption not being a random event. That is, we identify some household characteristics that are evaluated in the process of adoption of a child (e.g., parental age), and increase the likelihood of adopting a child.

Our results reveal that when both parents are overweight, children have an increased likelihood of being also overweight, irrespective of whether they are adopted or biological children. In contrast, when both parents are obese (and not just overweight), the likelihood of their offspring being overweight increases by 16.7 percentage points among biological children, but only by 4 percentage points when children are adopted. This suggests that transmission of overweight when both parents are obese is not merely genetic and that *vertical cultural* transmission plays an independent role.

When only the mother is overweight, we estimate the *cultural* transmission of overweight to be about 2.6 percentage points. In contrast, if the mother is

[3]We exclude those living with genetically related adoptive parents.

obese instead, we estimate the *cultural* transmission of overweight to be about 6 percentage points. In contrast, the transmission of paternal overweight and obesity is not significantly between adopted and biological children. These results suggests a stronger that maternal (compared to a paternal) influence on child overweight.

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

2 Empirical Strategy and Background

Our empirical strategy is grounded on a health production function framework that differentiates between genetic and environmental determinants of overweight. Health and non-health related traits of the parental environment influence child health production function creating links between the two generations. 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 exercise, and their exposure to healthier foods and exercise, and ultimately less likely to result in overweight. This model of transmission of overweight points towards distinguishing between sole maternal or paternal triggers of overweight from that of both parent's overweight. The latter,we expect,provides an additional reinforcing environmental effect.

As we explain below, we report estimates of different econometric specifications that compare the transmission of overweight across biological and adopted children. Estimates for non-biological children should remove the genetic components of transmission, and provides us with an idea of the potential parental influence in overweight.

We specify a linear model in which the latent overweight of a child is ex-

plained by parental characteristics (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 the mother or the father are overweight:

$$o_{ij}{}^{*} = \delta_0 + \gamma A_{ij} + \delta_M o_{ij}{}^{M} + \delta_F o_{ij}{}^{F} + \gamma_M A_{ij} o_{ij}{}^{M} + \gamma_F A_{ij} o_{ij}{}^{F} + \beta Z_j + \phi X_{ij} + v_{ij}, \quad (1)$$

where o_{ij}^{*} indicates the latent overweight of child i in household j; o_{ij}^{M} takes value one if the mother of child i in household j is overweight and zero otherwise; o_{ij}^{F} takes value one if the father of child i in household j is overweight and zero otherwise; A_{ij} is an indicator variable for the child being adopted; 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. Alternative specifications use an indicator variable that takes value one if *both* parents are obese or overweight and 0 otherwise instead of o_{ij}^{M} and o_{ij}^{F} .

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.:

$$P(o_{ij} = 1) = P(o_{ij}^{*} > 0) = \Phi(\delta_0 + \gamma A_{ij} + \delta_M o_{ij}{}^{M} + \delta_F o_{ij}{}^{F} +$$

$$+ \gamma_M A_{ij} o_{ij}{}^{M} + \gamma_F A_{ij} o_{ij}{}^{F} + \beta Z_j + \phi X_{ij}), \quad (2)$$

Coefficients δ_M and δ_F in equation (2) estimate the association between the mother and the father being overweight with the likelihood of the child being overweight, respectively; γ the association of being adopted with being overweight; and, most importantly, γ_M (γ_F) the additional effect on the association between the mother's (father's) overweight and the child's overweight if he or she is adopted.

Therefore, the significance of coefficients γ_M and γ_F will be informative of the existence of some *vertical cultural* transmission of overweight. By construction, their significance establishes whether the associations of the overweight of an adopted child with the overweight (obesity) of the adoptive mother and the adoptive father, respectively, are statistically significantly different than those that

apply to a natural child. The argument is that δ_M (δ_F for the father) measures the association of mother's overweight (or obesity) with her biological offspring and, thus, the transmission of overweight both via genetic and via *cultural* channels. Similarly, $\delta_M + \gamma_M$ measures that association for adopted children and therefore the transmission related to the environment (*cultural).* We also estimate variations of equation (2) in which we control for both parents being overweight or obese.

Given the categorical nature of the dependent variable, o_{ij}, we estimate all specifications using probit models. Ordinary east square (OLS) estimates are available in the Appendix, and suggest comparable effect sizes and precision.

The identification of the cultural transmission relies on the assumption that we control for enough observable characteristics of the child so that we manage to reduce the potential bias introduced by not being able to control for biological parent's information. A potential thread to the identification is the potential sample selection. That is, if adopted and biological children exhibit significant differences in their prevalence of overweight, then estimates will be biased. That said, our analysis described below suggests no significant effect of adoption on overweight. However, we still estimate a selection model which relies on an exclusion restriction related to the adoption regulations in the the United Kingdom, and more specifically, the age of the parents. We perform additional robustness checks re-estimating equation (2) separately for natural and adopted children which allows us to correct the potential bias introduced by the selection into an adoptive family. For these models we use probit models with sample selection.[4] The exclusion restriction for the identification of the Heckprobit models follows adoption rules in the United Kingdom, and relies mainly on parents' age criteria which influence

[4]i.e., Maximum-Likelihood probit models with sample selection as in Van de Ven and Van Praag (1981) were estimated using Heckprobit in Stata. Propensity score matching estimates did not suggest evidence of selection on observables

the likelihood of a child being adopted but not the child's being overweight.[5] We also include as covariates ethnicity and an indicator variable that takes value one if the household includes only the two parents and one child and zero otherwise.

Finally, we re-estimate equation (2) allowing the mother working full time to be associated to 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 and zero otherwise with the overweight indicator variables of the parents.[6]

3 Data

3.1 Health Survey for England

Our estimates employ fifteen years of data from the appended samples from 1997-2009 of the Health Survey for England (HSE), for which we could confidently identify adopted children. The HSE is an annual cross-sectional survey designed to measure health and health-related behaviours, and contains clinically reported measures of weight and height, which can be used to estimate the Body Mass Index (BMI) at the individual level for both adults and children living in private households in England. Although, the data set includes for some years blood based biomarkers and other clinical measures that allow measuring adiposity (e.g., waist circumference), they are not available for children. Hence, in constructing our sample, we have attempted to maximise the sample of adopted children (to gain precision in our estimates). Other relevant individual level variables such as

[5]We attempted to carry out a specific analysis of younger parents cut -off (around the age of 25, the minimum age to adopt a child) but there were not enough observations.

[6]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.

dietary habits and fruit consumption are not available in all waves, and in those waves that contain them, they are not available for all ages. This makes the sample of adoptees too small for a valid analysis.

Measures of overweight are clinically validated, and follow the international classification used in the literature (Cole, 2000), where individuals as overweight and obesity cut -off points are allowed to vary by age. [7] Alternative measures of weight such as BMI which are commonly used to measure obesity among adults are less precise, and potentially biased when examining child overweight. This is because they are subject to age specific changes in weight that the medical literature has long established. BMI exhibits a rapid increase during the first year of life of child, decreases until a child is 6 years of age, and, after that, BMI increases again throughout childhood (the latter is know as the 'adiposity rebound', Rolland-Cachera et al, 1984).

Our main sample contains a number of relevant records of adults and children in the household, alongside core information on all its members, including their relationship to other adults. 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 or related genetically.[8] Our pooled cross-section data set results from merging information contained different waves of the HSE.

3.2 Adoption in the UK

Adoption in the UK can be legally carried out by parents that are over 21 years of age that have at least one year of residency and have a fixed permanent home in

[7] Children's dietary patterns play a key role in the development of overweight. Excess caloric intake is responsible for excess fat in the body

[8] As we have the relationship between children and all relatives in the household, our sample does not include children living with 'non-parents' but biologically related family members, i.e. grandparents, uncles, aunts, etc.

the UK irrespective of the civil status. The latter allows the partner of the natural parent to be registered as an adoptive parent (UK Government, 2013);[9] in which case the partner is labelled 'step parent'. The process of adoption takes place after an application to an adoption agency (run by a council or a privately organisation). The conditions to be met to be regarded as 'suitable adopting parent' 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[10] . Recommendation decisions 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[11] and, so typically 'adoption' refers to adoption by non-family members.[12] Usually the Department of Education applies means tested fee for adoptive families to pay ranging from £885 to £1775 (UK Government, 2013).

Given the nature of our data set, 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, nor observe the weight of the biological parents. Second, we cannot identify the exact time of adoption, and can only indirectly control for it through age. Third, we cannot identify whether individuals were born overseas although we do have their ethnicity information.

[9]https://www.gov.uk/child-adoption

[10]We have performed a statistical test of equality of health between parents of biological and adopted children, and cannot reject the null hypothesis of equality of self-reported health

[11]Recent data from Adoption UK suggest that 75% of adopted children are between 1 and 4 years of age, 73% were from a white British background, and 91% of the adoptees were adopted by couples as opposed to single individuals. The number of adoptees was gender balanced, as 52% were boys and the remainder were girls (UK Government, 2013).

[12]As close relatives are typically asked before a child is put up for adoption.

3.3 Data Limitations

More generally, studies using data from adoptees face challenges that complicate the identification strategy (Holmlund et al, 2011). Parental sorting is not random. Adoption agencies often place infants selectively by matching natural and adoptive parent characteristics, such as education, occupation, and impressions about intelligence" (Scarr and Weinberg, 1994). Hence, if the genetic influence of the biological parents is not accounted for, statistical associations between the outcomes of adopted children and their adoptive parents might overestimate the adoptive parents' environmental influences. Unfortunately, very few studies have information on both biological and adoptive parents (Bjorklund et al. 2006).

In this study, we extend the analysis in several directions: First, we use clinically validated estimates of body mass index (BMI), overweight and obesity, which are age, and gender adjusted. This overcomes potential measurement errors in other surveys recording children estimates, e.g., Phipps et al. (2004) or Anderson et al. (2003). Second, our analysis focuses on the transmission of overweight rather than obesity, which extends previous findings. Third, we have access to socioeconomic information on both parents, which allows to control for the potential confounding effect of assortative mating (parents overweight might influence parental mating decisions) and, we examine the association when both parents shared the trait of being overweight. Fourth, as a robustness test, we correct for potential sample selection biases based on observables due to age based adoptee placement. In spite of this, there might still be unobserved characteristics we cannot control for, and there might be different sources of sample selection as parents of adoptees may attempt to undertake some compensating actions and behaviours. Lastly, we investigate if the transmission of overweight from parents to children is affected by the mother working full time.

We limit comparability of biological and adoptive family samples by restricting our analysis to two-parent households. Even though parents of adopted children typically compensate for the potentially detrimental effects of adoption on the

children's health behaviour's, which can explain that in our analysis we find limited evidence of selection.

Insert Table 1 here

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 (15,175 observations), and segregated by type of household, i.e. those in which both parents are biological (14,875 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 of equality of means between adopted and biological children, we observe that only in 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 systematically different. We do notice nevertheless that adopted children in the sample are slightly older than those in their biological parents' household; they are slightly more likely to have an obese parents; 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.[13] 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 (which includes obesity), about 40% for the former type

[13]Because there is a higher incidence of no-answer for the fathers' education, we create a NA education indicator that is included as a control.

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%; 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 to 6. In all tables, the dependent variable is stated in the top row of the top panel (the child being overweight) and the second row specifies whether the parents are overweight or obese.[14] Table 2 reports the estimates when we include an overweight/obesity indicator variable for the mother and/or the father . Table 3 reports the estimates of the transmission when we control for both parents being overweight or obese instead. Table 4 estimates the association differentiating when either both parents, or only the mother, or only the father are overweight or obese. We estimate three specifications for each model with an increasing number of controls, as specified at the bottom of the tables. Given the similitude of the estimates of interest across the specifications with

[14]Due to the small sample size of adopted children that are obese, we cannot analyse how parents being overweight or obese is associated to the child being obese.

different number of controls, our discussion focuses on the coefficients of the third specification, without loss of generality. Finally, note that, given the sufficient but limited number of adopted children our analysis, we ought to interpret our results as *conservative* estimates because the statistical insignificance of some variables might simply result from the sample size being small.

4.1 Main results

Table 2 presents the results of the specifications that include as explanatory variables whether the mother and/or the father are overweight or obese, and provide evidence of the average effect of each covariate on the probability of overweight. These results indicate that maternal overweight (obese) is associated with an increased likelihood of the child being overweight by 13.5 percentage points or pp (16.4pp). The increased likelihood of the child being overweight if the father is overweight (obese) is slightly smaller and equal to 10.9 pp (12.7 pp). Most importantly, the interaction term between one parent being overweight (obese) and the adoption status of the child is only significant for the case of the mother being overweight or obese. This means that being adopted only affects the association between parental overweight or obesity if the parent who is overweight or obese is the mother, but not the father. Lastly, as mentioned, the child being adopted is not significant when we control for the variation in their overweight. Also, note that being a single child or a girl raises the likelihood of being overweight by 4.8 pp and about 2.6 pp, respectively.

Insert Table 2 here

Estimates in Table 3 illustrate transmission of overweight when *both* parents are either overweight or obese. These results suggest that when both parents are overweight (obese), there is an increased likelihood of overweight among biological children by 14.7 pp (16.7 pp). The marginal effect of both parents being overweight (obese) on the likelihood of an adopted child being overweight, i.e. the coefficient

of the interaction between the indicator variable of both parents being overweight (obese) with the obesity of the child being adopted, is insignificant when both parents are overweight but negative and statistically significant when they are obese (-12.2 pp). This means that the association between the overweight of natural children with that of their parents is not statistically significantly different than that of adopted children. However, the association between both parents being obese and the child being overweight is larger for natural children (16.7pp) than for the adopted ones (16.7pp-12.2pp=4.9pp). Interestingly, and consistently with Table 2, the association of being adopted with the likelihood of being overweight is not statistically significant when we control for both parents being overweight but becomes significant and positive (10pp) when we control for the parents being obese. Another important result is that overweight parents are slightly more likely than obese parents to have overweight offspring, this result is consistent with the idea that obesity is largely genetically determined in contrast to overweight. Results in Table 3 reinforce previous evidence that transmission of obesity may be mainly genetic and thus natural children are more likely to be overweight if both parents are obese than adopted children are. Being a single child or a girl raises the likelihood of being overweight by very similar magnitudes than in Table 2.

Insert Table 3 here

Finally, Table 4 presents the estimates of the transmission of overweight when we control for both parents being overweight (obese), compared to *only* the mother or *only* the father being overweight (obese). These estimates are less precisely estimated due to the smaller number of observations in some of the categories which increase the standard errors, this table table contains fewer statistically significant terms involving the child being adopted but we still believe the results are interesting. When both parents are overweight there is an increased likelihood of the child being overweight (10.4 pp) for natural children but this is not the case for adopted children for which the likelihood decreases (10.4 pp - 11.6 pp = -1.2 pp). Interestingly, when both parents are obese, the probability of overweight does

not increase significantly for neither natural or adopted children. This result is consistent with the literature which suggests that whilst obesity is largely genetic, overweight is culturally transmitted. But, when only the mother is either overweight or obese, the likelihood of her children, being overweight increases by either 9.96 pp or 16.4 pp(if obese). In contrast, when only the father is either overweight or obese, the likelihood of child overweight increases by either 8.64 pp or 12.8 pp (if obese). A child does exhibit a higher probability of overweight (10.1 pp) if he or she is adopted when we control for the variation in parents' obesity but not if we control for their overweight, as in Table 2 and 3. Hence, our results are suggestive of no significant selection of adoptees into overweight.

In summary, from Tables 2 to 4, we can conclude that cultural transmission plays a role in explaining child overweight. That is, we find that the transmission is significantly different for adoptees and natural children, when both parents or the mother are overweight or obese.

Insert Table 4 here

4.2 Robustness Checks

As an extension, we study the transmission of overweight separately for natural and adopted children. The estimates for the adopted children sample are retrieved correcting for the sample selection using two-stage heckprobit models. We rely on the identifying assumption that age of the parents should not be related to the overweight, and instead exerts an influence on the probability of a child adoption. Our estimates are very similar to the estimates in Table 2 and 3. This is not surprising given that natural children represent the overwhelming majority of the sample used to estimate coefficients in those two tables. Thus, our results corroborate that the overweight and the obesity of either parent or both parents are associated to an increased likelihood of their children being overweight.

5 Discussion

Our results suggest that children's overweight is related to the overweight and obesity of the parents even when there are no genetic linkages between them as is the case of adoptees: when both parents are overweight, children have an increased likelihood of being also overweight, irrespective of whether they are adopted and natural children. When both parents are obese as opposed to overweight the likelihood of their offspring being overweight increases by 16.7 percentage points for natural children and by 4.5 percentage points for adopted children. If the mother is overweight, the *cultural* transmission of overweight is 2.6 percentage points but if she is obese instead, the *cultural* transmission of overweight is larger. The father being overweight or obese is associated to the overweight of his children independently of their adoption status.

Our paper contributes to the 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. We rely on a dataset, the HSE, that contains clinically measured height and weight for adopted and biological children and their living-in parents, alongside 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 intergenerational transmission for education (Holmlund et al, 2011) reveals that for obesity, genes play a larger role than for overweight, which is quite sensitive to changes in the environment. This is consistent with other studies that do not disentangle total from cultural transmission (Classen and Hokayem 2005; Classen, 2010; Costa-Font and Gil, 2013).

Our estimates are subject to several limitations imposed by the nature of the data. First, adopted children health might differ between adopted and biological children, 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. 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 access to information on the characteristics of biological parents of the adoptees, and whether the children were foreign born or not. To address some of these biases, we have compared the two types of households to ensure they are not significantly too different and still correct for sample selection biases.

We have also run robustness checks using different specifications. Finally, the sample of overweight adopted children is small, and the number of those who have obese parents even smaller. Although this hinders the statistically significance of our results regarding the cultural transmission of obesity from parents to children, this means also that our estimates might be providing a lower bound of the effect.

6 Conclusion

This paper has drawn upon a uniquely constructed data set of English adoptees to investigate the inter-generational transmission of overweight. 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 estimate our empirical models of overweight exploiting data on two types of children, those living with both their natural parents and those living with adoptive parents and control for a battery of the households' socioeconomic characteristics that could explain variations in children overweight and obesity.

We conclude that this paper provides evidence in favour of the hypothesis that there is a cultural transmission of overweight especially when both parents are overweight or obese. When both parents are overweight (obese), we estimate an average increased likelihood of overweight among biological children by 14.7 pp (16.7) pp (out of an average overweight of 0.23). The importance of both parents being overweight in explaining the overweight of the children can be explained by some level of assortative mating, or alternatively a reinforcing environmental effect that takes place when both parents adopt similar behaviours. One hypothesis is consistent with assortative mating is that health and lifestyle preferences influence 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. Some of our results suggest, nevertheless, that, as some studies show (Lake et al., 2006), food responsibility may be still predominately female dominated, but the ingest of such food might be more than proportionally consumed by men and children.

Our results suggest that that there is room to design preventative policies to tackle children's overweight and obesity, by influencing parental overweight and their lifestyles. Ideally, both parents should be included for the effect for the policy to be more effective. Child overweight is partly inter-generationally transmitted, and the pathway seems to be primarily the children environment. In contrast, and consistently with the behavioural generics literature, obesity exhibits a highly genetic component. The latter does not imply that policy interventions will not be effective, but that, for obesity, effective interventions need to expand beyond the environmental drivers of the condition.

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Table 1. Summary statistics

Reference person	Variable (*** Significant differences)	Overall Sample	Natural/Biological	Adopted
	Number of Observations	15175	14875	300
Child	Obese Child	5.56%	5.56%	5.55%
	Overweight Child	23.5%	23.5%	25.3%
	Age of Child***	9.1	9.0	10.9
	Female Child	49.1%	49.2%	46.3%
Parents' Obesity	Only Mother Obese	19.4%	19.4%	20.7%
	Only Father Obese	19.3%	19.4%	16.2%
	Only Mother Overweight	16.2%	16.1%	17.6%
	Only Father Overweight	26.3%	26.4%	21.7%
	Both parents Obese***	27.7%	27.5%	20.8%
	Both parents Overweight**	39.9%	39.9%	46.0%
Parents'	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%
	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%
	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%
	Father at Home	1.3%	1.3%	2.0%
	Father Employed	90.4%	90.4%	88.3%
	Father Retired	0.7%	0.7%	1.7%
	Father 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
	Income (£)	30,899.11	30,913.34	30,257.37
	Own Flat (respondents owns property)	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 ***	22.9%	22.7%	31.3%

Notes: This table provides the summary statistics of the variables used. We distinguish between natural and adopted children. 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. Probability of Child Overweight and Parental/Maternal Overweight / Obesity – Probit specification

	(1) Basic	(2) Controls_1	(3) Full Controls	(4) Basic	(5) Controls_1	(6) Full Controls
Mother Obese/Overweight	0.131***	0.131***	0.129***	0.110***	0.111***	0.109***
	(0.0255)	(0.0259)	(0.0260)	(0.0251)	(0.0255)	(0.0256)
Child Adopted	0.160**	0.157**	0.183***	0.0910*	0.0917*	0.106**
	(0.183)	(0.182)	(0.190)	(0.145)	(0.145)	(0.154)
Mother Obese/Overweight *Adopted	-0.0980**	-0.0945**	-0.0923**	-0.0662	-0.0623	-0.0607
	(0.174)	(0.174)	(0.179)	(0.174)	(0.174)	(0.177)
Father Obese/Overweight	0.0942***	0.0941***	0.0968***	0.0712***	0.0726***	0.0744***
	(0.0273)	(0.0275)	(0.0277)	(0.0251)	(0.0253)	(0.0254)
Father Obese/Overweight *Adopted	-0.0707	-0.0674	-0.0794	-0.0605	-0.0619	-0.0686
	(0.180)	(0.180)	(0.185)	(0.171)	(0.172)	(0.175)
Controls	None	Controls_1	Full Controls	None	Controls_1	Full Controls
Observations	15175	15164	15162	15175	15164	15162
Likelihood Ratio Estimates	-7988.576	-7945.913	-7901.913	-8065.194	-8019.325	-7975.552

Notes: This table reports the marginal effect estimates of a probit model in which the dependent variable measures child overweight. Our independent (treatment) variables include whether the mother or the father or both are overweight (first panel 1-3) or obese (second panel 4-6), whether the child is adopted and the interaction between the overweight of the parents and being adopted. The controls included in each specification are as follows: Basic (none), Controls_1 (Female Child; White; Single child; Year; Long Illness; Ethnicity; Rural dwelling; Household Size), Full Controls (Controls_1 plus Number of Siblings in the Family, Mother Works Full Time; Natural Father; Mother Mental Health Problems; Father Mental Health Problems; Mother Education; Father's Education; Lives in Own Flat; Income; Passive Smoking. Maternal employment). Overweight includes obesity. Robust Standard Errors, Clustered by household and Bootstrapped, in parentheses. * p<.10 ** p<.05 *** p<.01

Table 3. Probability of Child Overweight – Heterogeneity by adopted and biological child

	(1) Basic	(2) Controls_1	(3) Full controls	(4) Basic	(5) Controls_1	(6) Full Controls
Both Obese/Overweight	0.230***	0.231***	0.231***	0.195***	0.197***	0.198***
	(0.0384)	(0.0389)	(0.0391)	(0.0316)	(0.0322)	(0.0323)
Child Adopted	0.156*	0.155**	0.183**	0.0957*	0.0970*	0.114**
	(0.232)	(0.229)	(0.236)	(0.161)	(0.161)	(0.171)
Both Obese/Overweight *Adopted	-0.144**	-0.140**	-0.147**	-0.116**	-0.114**	-0.119**
	(0.262)	(0.259)	(0.263)	(0.211)	(0.211)	(0.216)
Only Mum Obese/Overweight	0.114***	0.116***	0.111***	0.0950***	0.0958***	0.0922***
	(0.0458)	(0.0461)	(0.0463)	(0.0355)	(0.0358)	(0.0359)
Only Mum Obese/Overweight *Adopted	-0.0933	-0.0923	-0.0919	-0.0718	-0.0692	-0.0703
	(0.303)	(0.301)	(0.309)	(0.241)	(0.242)	(0.250)
Only Dad Obese/Overweight	0.0777***	0.0783***	0.0793***	0.0516***	0.0527***	0.0531***
	(0.0417)	(0.0420)	(0.0421)	(0.0362)	(0.0364)	(0.0365)
Only Dad Obese/Overweight *Adopted	-0.0675	-0.0668	-0.0809	-0.0697	-0.0727	-0.0826
	(0.291)	(0.289)	(0.297)	(0.272)	(0.272)	(0.278)
Controls	None	Controls_1	Full Controls	None	Controls_1	Full Controls
Observations	15175	15164	15162	15175	15164	15162
Likelihood Ratio	-7985.114	-7942.596	-7897.925	-8060.998	-8015.002	-7970.548

Notes: This table reports the marginal effect estimates of a probit model in which the dependent variable measures child overweight. Our independent (treatment) variables include whether the mother or the father or both are overweight (first panel 1-3) or obese (second panel 4-6), whether the child is adopted and the interaction between the overweight of the parents and being adopted. The controls included in each specification are as follows: Basic (none), Controls_1 (Female Child; White; Single child; Year; Long Illness; Ethnicity; Rural dwelling; Household Size), Full Controls (Controls_1 plus Number of Siblings in the Family, Mother Works Full Time; Natural Father; Mother Mental Health Problems; Father Mental Health Problems; Mother Education; Father's Education; Lives in Own Flat; Income; Passive Smoking. Maternal employment). Overweight includes obesity. Robust Standard Errors, Clustered by household and Bootstrapped in parentheses.
* p<.10 ** p<.05 *** p<.01

Table 4: Parents' Overweight/Obesity and Overweight Children's Associations

	Parents Overweight					
	Maternal overweight (natural child overweight)	Maternal overweight (adopted child overweight)	Paternal overweight (natural child overweight)	Paternal overweight (adopted child overweight)	Both overweight (natural child overweight)	Both overweight (adopted child overweight)
Mother or Father (or both)	12.9	12.9-9.2=3.7	9.6	9.6-7.9§=1.7		
Only Mother, Only Father or Both	11.1	11.1-9.1§=2	7.9	7.9-8§=-0.1	23.1	23.1-14.7=8.4
	Parents Obesity					
	Maternal overweight (natural child overweight)	Maternal overweight (adopted child overweight)	Paternal overweight (natural child overweight)	Paternal overweight (adopted child overweight)	Both overweight (natural child overweight)	Both overweight (adopted child overweight)
Mother or Father (or both)	10.9	10.4-6.0§=4.4	7.4	7.4-6.8§=0.6		
Only Mother, Only Father or Both	9.2	9.2-7§=2.2	5.3	5.3-8.2§=2.9	19.8	19.8-11.9=7.9

Note: This table shows the overall associations between rows and columns, given the coefficients of the interaction terms in in Tables 2 and 3. Coefficients followed by § are not significant.

Appendix

Table A1: Ordinary Least Square Models - Mother and/or Father overweight

	OLS					
	(1)	(2)	(3)	(4)	(5)	(6)
Ob/Ov means that parents are:	Overweight			Obese		
Child is:	Overweight			Overweight		
Mum Ob/Ov	0.136***	0.136***	0.134***	0.163***	0.163***	0.163***
	(0.00766)	(0.00770)	(0.00738)	(0.00999)	(0.0104)	(0.0105)
Child Adopted	0.0521	0.0509	0.0660	0.0630*	0.0627*	0.0776**
	(0.0479)	(0.0481)	(0.0509)	(0.0352)	(0.0339)	(0.0378)
Mum Ob/Ov*Adopted	-0.135***	-0.132**	-0.129**	-0.137*	-0.132**	-0.137**
	(0.0523)	(0.0525)	(0.0636)	(0.0707)	(0.0621)	(0.0608)
Dad Ob/Ov	0.104***	0.103***	0.107***	0.127***	0.126***	0.127***
	(0.00854)	(0.00741)	(0.00681)	(0.0102)	(0.00961)	(0.00871)
Dad Ob/Ov*Adopted	0.0441	0.0447	0.0398	-0.0866	-0.0844	-0.0866*
	(0.0543)	(0.0587)	(0.0524)	(0.0571)	(0.0620)	(0.0474)
Girl		0.0478***	0.0475***		0.0486***	0.0482***
		(0.00799)	(0.00687)		(0.00735)	(0.00677)
Single		0.0287**	0.0236*		0.0281*	0.0249*
		(0.0130)	(0.0141)		(0.0161)	(0.0147)
White		0.0143	0.0127		0.0156	0.0124
		(0.0103)	(0.00986)		(0.0102)	(0.00986)
Intercept	0.0883***	0.0656**	0.0249	0.171***	0.146***	0.0772
	(0.00581)	(0.0314)	(0.0904)	(0.00475)	(0.0293)	(0.0805)
Controls	C0	C1	C2	C0	C1	C2
Observations	15175	15164	15162	15175	15164	15162
R2	0.041	0.045	0.051	0.045	0.049	0.055
Likelihood	-8204.669	-8163.789	-8116.128	-8169.434	-8128.440	-8084.531

Controls C0: None.

Controls C1: Girl; White; Single child; Year; Long Illness; Ethnicity; Rural dwelling; Household Size.

Controls C2: Girl; White; Single child; Year; Long Illness; Ethnicity; Rural dwelling; Household Size; Number of Siblings in the Family, Mother Works Full Time; Natural Father; Mother Mental Health Problems; Father Mental Health Problems; Mother Education; Father's Education; Lives in Own Flat; Income; Passive Smoking.

Robust Standard Errors, Clustered by household and Bootstrapped in parentheses. * p<.10 ** p<.05 *** p<.01

The dependent variable is whether the child is overweight. We show the ordinary least square estimates for the parameters of interest: whether only the mother, only the father or both are overweight (first panel) or obese (second panel), whether the child is adopted and the interaction between the overweight/obesity of the parents and being adopted. The controls included in each specification is below the table.

Table A2: OLS Models - Only Mother, Only Father or Both Being Overweight/Obese

	OLS					
	(1)	(2)	(3)	(4)	(5)	(6)
Ob/Ov means that parents are:	Overweight			Obese		
Child is:	Overweight			Overweight		
Both Ob/Ov	0.228***	0.227***	0.228***	0.302***	0.302***	0.303***
	(0.00767)	(0.00873)	(0.00934)	(0.0205)	(0.0168)	(0.0156)
Child Adopted	-0.000416	-0.00416	0.0126	0.0755***	0.0757***	0.0881**
	(0.0422)	(0.0431)	(0.0486)	(0.0288)	(0.0282)	(0.0406)
Both Ob/Ov*Adopted	-0.0554	-0.0493	-0.0533	-0.171	-0.163	-0.181*
	(0.0635)	(0.0598)	(0.0623)	(0.116)	(0.116)	(0.0935)
Mum Ob/Ov	0.0926***	0.0935***	0.0880***	0.155***	0.155***	0.154***
	(0.0113)	(0.0108)	(0.0120)	(0.0101)	(0.0138)	(0.0135)
Mum Ob/Ov*Adopted	-0.0242	-0.0156	-0.0167	-0.190***	-0.187***	-0.183**
	(0.0857)	(0.0928)	(0.0839)	(0.0658)	(0.0674)	(0.0812)
Dad Ob/Ov	0.0740***	0.0737***	0.0756***	0.119***	0.118***	0.118***
	(0.00743)	(0.00929)	(0.00757)	(0.0124)	(0.0119)	(0.0118)
Dad Ob/Ov*Adopted	0.120*	0.124*	0.117*	-0.136	-0.136**	-0.128*
	(0.0643)	(0.0647)	(0.0703)	(0.0979)	(0.0615)	(0.0766)
Girl		0.0476***	0.0473***		0.0486***	0.0482***
		(0.00707)	(0.00767)		(0.00656)	(0.00766)
Single		0.0285**	0.0233		0.0283**	0.0251**
		(0.0134)	(0.0168)		(0.0126)	(0.0119)
White		0.0144	0.0127		0.0155	0.0122
		(0.00963)	(0.00842)		(0.00983)	(0.0102)
Intercept	0.109***	0.0839***	0.0463	0.173***	0.148***	0.0817
	(0.00577)	(0.0318)	(0.0863)	(0.00400)	(0.0257)	(0.0673)
Controls	C0	C1	C2	C0	C1	C2
Observations	15175	15164	15162	15175	15164	15162
R2	0.042	0.046	0.052	0.045	0.050	0.055
Likelihood	-8196.241	-8155.534	-8106.679	-8166.961	-8125.840	-8082.096

Controls C0: None.

Controls C1: Girl; White; Single child; Year; Long Illness; Ethnicity; Rural dwelling; Household Size.

Controls C2: Girl; White; Single child; Year; Long Illness; Ethnicity; Rural dwelling; Household Size; Number of Siblings in the Family, Mother Works Full Time; Natural Father; Mother Mental Health Problems; Father Mental Health Problems; Mother Education; Father's Education; Lives in Own Flat; Income; Passive Smoking.

Robust Standard Errors, Clustered by household and Bootstrapped in parentheses. * p<.10 ** p<.05 *** p<.01

The dependent variable is whether the child is overweight. We show the ordinary least square estimates for the parameters of interest: whether only the mother, only the father or both are overweight (first panel) or obese (second panel), whether the child is adopted and the interaction between the overweight/obesity of the parents and being adopted. The controls included in each specification is below the table.