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Childhood Disadvantage and Obesity: Is Nurture Trumping Nature?

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I. Introduction

Obesity has been one of the fastest growing health concerns among children, particularly among disadvantaged children. Childhood obesity has risen starkly over the last three decades. For children overall, obesity rates have tripled from 5% in the early 1970s to about 15% by the early 2000s. For disadvantaged children, the rates of obesity are even higher. In 1999-2002, 18% of low income children (those whose family incomes were in the bottom quintile) and 19% of African-American children qualified as obese.

Obesity carries with it both short term and long term consequences. Obese children have higher incidences of type II diabetes, for example, and lower quality of life scores. In addition, obese children are much more likely than normal weight children to become obese adults, and obese adults are more likely to suffer disability during their prime working years, and have adverse health outcomes like hypertension, heart attack and cancer. While the precise impact of obesity on mortality remains a matter of debate, there is little debate that obesity increases morbidity and its attendant health care costs. Since disadvantaged children and adults have higher rates of obesity than other segments of the population, they suffer more of the short term and long term consequences of this condition.

Understanding the increase in childhood obesity is important for devising policies to deal with this health problem. Although recent research and policy activity surrounding this issue has focused particularly on the food available to children through schools, there is a gap in our knowledge when it comes to the impact of home environment on children's obesity. To address this question, we ask how does parental obesity relate to children's obesity? Is this different for disadvantaged families? Have these relationships changed over time? Parental obesity is very closely tied to children's obesity, for reasons of both nature and nurture. First, there is a strong

genetic component to body composition. Second, parents and children share many environmental characteristics. Additionally, parents have a great deal of influence over what their children, particularly their young children, eat and how much energy they expend. Since genetics are unlikely to have changed dramatically over the past twenty years, if the correlation between parents' and children's obesity has changed over time, then it is likely that the environment and/or parental behavior has changed. If the overall correlation has increased over time, it suggests that something is changing in the common environment (or decisions made by the family) that is affecting all family members. On the other hand, if the correlation has decreased over time, then it suggests a larger role for something unique to the environment that children face, for example in child care settings and public schools.

Most importantly for this paper, there may be important differences in the relationship between parents' and children's obesity for disadvantaged children. For example, if the parent-child correlation is lower for the disadvantaged, then it suggests that environmental factors may be more important than the fixed genetic component for this group. Again, if the relationship is changing over time, it provides clues as to changes in the environment that may be contributing to the changes in obesity. Thus, this paper focuses on a fundamental component of health status, obesity, for which disadvantaged children have particularly poor outcomes. It sheds light on how parents' health status is related to children's health status, and how that relationship differs for disadvantaged and advantaged children.

II. Previous Research in this Area

Economic research on obesity has focused on changes in the (implicit) prices of food and exercise that have increased caloric intake and reduced energy expenditure (Cutler, Glaeser and

Shapiro, 2003; Lakdawalla and Philipson, 2002). While this work is important, it is not clear how well it applies to children, especially young children, who typically do not select the menu of food presented to them, nor do they have complete control over how they spend their time. Thus, work on childhood obesity has focused on changes in children's environment that may have tilted their energy balance toward consuming more calories and expending less energy. For example, work has focused on changes in maternal employment (Anderson, Butcher, Levine, 2003), and changes in the food environment and physical activity available to children through schools (Anderson and Butcher, 2006b; Schanzenbach, 2005; Cawley et al., 2007), and how these changes in the two institutions, families and schools, in which children spend most of their time, may have affected obesity.

There is, of course, a substantial literature outside economics on childhood obesity. Much of this focuses on whether children who consume more of specific types of foods (e.g. fast food, soda) or engage in particular activities (e.g. television watching, video game playing) are more likely to be obese (see Anderson and Butcher, 2006a for a summary of this literature). In addition, there is a large literature documenting that children from disadvantaged backgrounds are more likely to have weight problems than others (see e.g. Strauss and Pollack, 2001). Finally, there is a large literature documenting the genetic component of obesity (see e.g. Stunkard et. al., 1990).

What we believe is missing is a better understanding of whether the obesity epidemic in children is simply part and parcel of the obesity epidemic in adults, or whether it represents a related, but separate, phenomenon. Is it the case that parents are making poorer nutrition/exercise choices for themselves and their children now than they did in the past? On the other hand, are there changes in the specific environments that children face that have

changed the relationship between their and their parents' obesity? For example, a parent who walks to work (and gets her exercise that way) may not feel comfortable letting her child walk to school or play outside after school, because of criminal activity or more mundane (but clearly valid) concerns over traffic safety. There is good reason to suspect that these concerns may differ by advantaged and disadvantaged families, making it important to study the role of disadvantage in this parent-child correlation in obesity over time.

III. Background Facts

A. Trends in Obesity

Obesity for adults is defined as having a body-mass-index[1] (BMI) of 30 or above. Children are classified as obese if they have a BMI above the 95th percentile of an age-sex specific BMI distribution (calculated with data that pre-dates the current increase in obesity).[2] Using several years of National Health and Nutrition Examination Survey (NHANES) data, Figures 1 and 2 demonstrate that obesity has increased for both adults and children. The first thing to note about these figures is that there is very little change between the first two NHANES periods. The real increase in both adult and child obesity is between NHANES 2 and NHANES 3. That is, obesity in the U.S. really began to increase noticeably sometime during the early 1980s. The second thing to note from these figures is that there is a strong negative relationship between income and obesity for adults even in the first period, while for children this relationship is less apparent until the later periods. In the first period, obesity rates for children in the wealthiest families are about two-thirds of the obesity rates of children in the

[1] Weight in kilograms divided by height in meters squared.
[2] The nomenclature in the medical literature is different for children and adults. Children whose BMI is above the 95th percentile for their age-sex distribution are called "overweight" and those above the 85th percentile are called

poorest families. By the last period, obesity rates of all groups of children have increased, and the difference in obesity rates between the richest and poorest families has increased slightly. For the adults, all groups are becoming more likely to be obese, with the higher income groups appearing to "catch up" to some extent to the lower income groups.

In many ways, the adults appear to be leading indicators for the children. That is the children's relationship between obesity and income in the last period looks very similar to that of the adults in the first period. This may mean that in the future the effect of disadvantage on children's obesity will become less extreme.

Note that solely focusing on the obesity cutoffs masks the increase in inequality in BMI. The obesity epidemic is characterized by a thickening of the right tail of the BMI distribution: the heavy are getting much heavier (Anderson and Butcher, 2006a). Thus, obesity rates have increased and BMI among the obese has increased. Among the obese, disadvantaged children tend to have higher average BMI in any given time period. However, note that differences in the age-sex composition of the population may drive the differences in average BMI among the obese across time periods and between advantaged and disadvantaged groups. In our regression analyses, we examine the natural log of BMI and control for a cubic in age, gender, and interactions between these variables.

B. Data

To address the question of how the parent-child correlation in BMI has changed over time for disadvantaged and non-disadvantaged groups, we rely on four waves of the National Health and Nutrition Examination Survey. The data were collected in 1971-1974 (NHANES 1),

"at-risk-for-overweight." In order to simplify the discussion, we will use the adult terminology for both children and adults.

1976-1980 (NHANES 2), 1988-1994 (NHANES 3). A fourth wave was begun in 1999 and we use data through 2004 for this wave.

The NHANES are the most frequently used data for tracking obesity trends in the U.S. population. The data are a nationally representative sample. The data collection procedures include an examination component, so the children in our sample were weighed and measured by trained personnel. These measurements go into our calculation of BMI for children.

There are some drawbacks to these data for our purposes. There are changes over time in the information that was collected that limit some of the analyses we can conduct. Further, not every child in the sample has a parent in the sample. Thus, in order to examine the relationship between parent and child BMI, we use a measure of child's BMI that is calculated from the examination data, but a measure of parental BMI that is reported on the child's health history record.[3] Reported BMI are only available consistently across the years for children under 12. Thus, we focus on children 2-11 years old. In addition to the restrictions imposed by data availability, questions about the impact of parental choices on children's BMI may be particularly germane for this group since adults are likely to have a greater influence over these children's food and exercise options than would be the case for teenagers. Thus, pre-teens seemed like the most appropriate group to analyze.

We capture "disadvantage" using three different measures: race/ethnicity, education levels, and family income. Being non-white and/or Hispanic is associated with disadvantage. Coming from a household where the reference person has less education is correlated with lower socioeconomic status. Finally, we use the family income relative to the poverty line for that family's size and time period. Family income is only available in bracketed form in the

[3] We can match children to adults within the household, but in the first two waves of the NHANES this results in a losing about ¾ of our sample.

NHANES. However, a "poverty index" or income-to-poverty ratio is available in all four waves and is meant to allow for comparisons of economic well-being across time periods.[4]

C. Changes in BMI over time by measures of Disadvantage

Before turning to the parent-child correlation in BMI, we first present simple regressions of log BMI on various measures of disadvantage for our four time periods. These regressions control for a cubic in age, gender, and interactions between these variables. This should control for the fact that as children age, we expect their BMI to increase, and to increase at different rates for boys and girls. We control for age and gender in the regressions so that differences in BMI by measures of disadvantage will not be due to differences in the age-sex composition across these groups.

The top panel of Table 1 presents regressions of log BMI on racial and ethnic categories.[5] The second panel shows regressions of log BMI on the highest grade of the household reference person. The third panel shows the results for the income-to-poverty ratio. The fourth panel includes all measures of disadvantage simultaneously**.** In all years, there is evidence that disadvantaged children are heavier, although the strength of that correlation varies with the measure and the time period. For example, black children do not have significantly higher BMIs than white children prior to 1980. By the 1988-1994 wave of the NHANES, however, black children have 1.0 percent higher BMI. By the 1999+ wave, that had increased to 2.1 percent higher BMI. For an 8 year old girl of median height (4'2") and weight (56 pounds), this is the equivalent of a 1.2 pound weight gain. Hispanic children have significantly higher BMIs than white non-Hispanic children across all time periods, and the difference appears larger in the later

[4] Of course, the poverty line is itself calculated. If an income at or below the poverty line represents a different degree of disadvantage in different time periods, then this variable is not a comparable measure of disadvantage over these time periods. Income-to-poverty ratio ranges from 0.0 to 8.9 with a mean of 2.12 in NHANES 1, from 0 to 6

periods. Prior to 1980, children from families with higher income-to-poverty ratios did not have significantly lower BMIs. After 1988, however, that correlation is negative and statistically significantly different from zero, and becoming steeper over time. Being from a household where the reference person has a higher level of education is statistically significantly negatively correlated with BMI in the first three time periods – we do not yet have information on the reference person's education in the fourth wave. When we include all measures of disadvantage simultaneously we find that, once the income-to-poverty ratio and education are held constant, being black no longer is significantly positively correlated with BMI in any of the years, but being Hispanic is still associated with a higher BMI. Each additional year of education of the household reference person is associated with at 0.2 to 0.5 percent reduction in BMI. In the last wave, the income-to-poverty ratio is negatively and significantly correlated with children's BMI. These regressions show that disadvantaged children are heavier. Additionally, measures of disadvantage explain a higher fraction of the variation in children's log BMI after 1988.

Before we examine parent-child correlations in BMI, we examine the relationship between caloric in-take and our measures of disadvantage. The NHANES 24-hour food recall data allow us to examine whether and how measures of disadvantage are associated with overall (reported) caloric in-take, and even in-take of calories from certain types of foods. Table 2 shows regressions of the log of total calories, log of calories from fruits and vegetables, and the log of calories eaten outside the home on the income-to-poverty ratio, holding constant a cubic in age fully interacted with gender.[6] We choose to examine the relationship between calories and the income-to-poverty-line ratio as it is available in all waves of the NHANES. The regressions

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with a mean of 2.0 in NHANES 2, from 0 to 8.5 with a mean of 2.2 in NHANES 3, and 0 to 5 with a mean of 2.3 in NHANES 4.

[5] Note that the sample is restricted to children for whom we have a valid BMI observation for their mother.

show an inconsistent pattern in the correlation between the income-to-poverty line ratio and total calories. In the first wave, the relationship is positive, but insignificant. In the second wave, it is positive and significant – meaning that children from wealthier families report consuming more calories. In the third wave it is negative and significant; in the fourth, it is very small and insignificant. Thus, if anything, we observe a change between NHANES 2 and 3 in which disadvantage no longer implies fewer calories, but rather more calories, but that in more recent years, all children have similar caloric intake. This pattern is consistent with the idea that while disadvantaged children are heavier, the non-disadvantaged are gaining ground. One way for this to occur is for caloric intake to become more similar. Recall, though, that as noted by other researchers (Glaeser et. al., 2003, Schanzenbach, 2005) the literature that tries to pin down the effect of caloric in-take on BMI has a very hard task. A very small calorie imbalance can, over time, lead to a large increase in BMI. Trying to detect small calorie differences from individual reports of calorie consumption is challenging. And even if we had a very good measure of calorie in-take, we are missing the caloric expenditure side of the equation.

Instead of only examining total calories – which if well-measured are what ought to matter for weight gain or loss – we examine calorie in-take from fruits and vegetables and calories consumed away from home. Consumption of fruits and vegetables may be viewed as a "marker" of healthy eating, and thus may give us some insight into how disadvantage may correlate with food consumption. Similarly, we examine calories from food consumed away from home.[7] One popular explanation for the rise in obesity is that consumption of food from fast food and other restaurants has increased. The notion is that with professionally prepared

[6] We add 1 to the calorie measure so that we can include log(calories) even for those who do not consume any calories from a given source, and to total calories to be consistent.
[7] Note that this includes food consumed at school as well as food consumed in restaurants. Thus it likely is picking up the fact that low-income children get more calories from school through lunch and breakfast programs.

food individuals are less aware of the calorie content of what they are eating, have less control over portion size, and may find the food more palatable, than food prepared at home. Note that French fries are included in this measure of fruits and vegetables[8] – for some of the years we can separate out certain food types and food venders and we will do that when we examine parent-child correlations in calorie consumption. For now, note that the second column of Table 2 indicates that in the first three NHANES, higher income is associated with significantly more calories from fruits and vegetables. In the last two NHANES, higher incomes are associated with significantly more calories consumed away from home. Thus, there is some evidence that advantaged and disadvantaged children consume calories from different sources, and that these relationships may have changed over time. However, with these broad measures of caloric in-take it is hard to see how this may translate into differences in BMI.

IV. Parents' and Children's Body Mass

A. Mothers and Fathers

Parents and children share common genetics, and, if they live together, share a common environment. Thus, we expect to see a strong correlation between the BMI of parents and children. Since we do not expect that the underlying genetic predisposition toward obesity will have changed over the twenty or so years that childhood obesity has been increasing, examining changes in the parent-child correlation in BMI should give us some insight into the ways in which the environment that parents and children share has affected children's body mass. We investigate the parent-child correlation in BMI by running regressions of log(Child's BMI) on log(Parent's BMI). The coefficient on log(Parent's BMI) tells us the elasticity of children's BMI

[8] As Glaeser, Cutler and Shapiro (2003) point out, French fries are America's favorite vegetable and consumption has expanded over time.

with respect to their parents – a one percent increase in parent's BMI is correlated with what percent increase in children's BMI. A larger elasticity implies a greater role for the common environment that parents and children share; a smaller elasticity implies a greater role for environments that children do not share with their parents.

Table 3 presents regressions of the log of child's BMI on his or her mother's log BMI (column 1), his or her father's BMI (column 2), and both simultaneously (column 3). These regressions control for race, ethnicity, education of the reference person, the family's income-to-poverty ratio, and a cubic in the child's age fully interacted with gender. The three panels present the evidence for the three waves of the NHANES for which we have reported information on mothers' and fathers' height and weight.[9] The results in the first panel show that a 10 percent increase in either mothers' or fathers' BMI is correlated with about a 1.4 percent increase in child's BMI. When both parents' BMI measures are in the regression the individual coefficients decline somewhat – as is to be expected since mothers' and fathers' BMI are correlated as well – but both are statistically significant.[10] If children, on average, shared the same amount of common genetics with their mothers and their fathers, but shared more common environment with their mothers we might expect that mothers' BMI would be more important in explaining children's BMI than fathers' – as mothers' BMI would pick up both the effect of common genetics and common environment. These results suggest that there the common environment shared by mothers and their children and fathers and their children is similar. One caveat to this is that fathers' reported BMI is more likely to be missing than mothers. Thus, one might say that the parent-child correlation in BMI is about the same for fathers and mothers,

[9] We have recently received approval to use confidential information in the 1999+ wave of the NHANES that will allow us to match children with adults in their household. We plan to add this evidence to the paper. Note this requires a switch in the independent variables from reported parental BMI to a matching strategy where we match

when the father is present. Since including fathers' BMI in the regression does not make much difference to the estimated mother-child correlation in BMI and we lose observations when we require non-missing father BMI data (and those children who are missing fathers' BMI data are more likely to be disadvantaged), we focus on mother-child BMI elasticities in the analyses that follow.

Looking down the panels in Table 3 we can see how the mother-child BMI elasticity has changed over time. Between the first and second wave of the NHANES, recall, children's obesity rates and BMIs do not change very much. Here we see that the mother-child BMI elasticity is nearly identical in these two periods as well, implying that a 10 percent increase in mothers' BMI is correlated with a 1.4 percent increase in children's BMI. In the third wave of the NHANES, the mother-child elasticity is even larger. A 10 percent increase in mothers' BMI is correlated with a 2.1 percent increase in children's BMI.

Average BMI for mothers increased by 4.1 percent over this time period (see Appendix Table 1). Using the mother-child elasticity from 1976-1980, we would have expected children's BMI to increase by 0.58 percent.[11] Using the mother-child elasticity from 1988-1994, we would have expected children's average BMI to increase by 0.84 percent. Average BMI for children aged 2-11 actually increased by 2.8 percent between the second and third waves of the NHANES. Clearly, there are other factors besides the shared genetic-environmental factors of mothers and children that are driving the increase in children's BMI. However, over this time period, it appears that the shared mother-child factors became more important.

B. Differences in Mother-Child Elasticities by Measures of Disadvantage

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the child with an adult "likely" to be his or her mother and father. We have used this matching strategy in the NHANES 3 find very similar results to those calculated using reported parental BMI.

[10] Results look similar if the child's own birthweight is included as a control variable.

[11] Percentage change in children's BMI = (elasticity* percentage change in mothers' BMI)=(0.141*4.1percent)

Table 4 investigates whether the mother-child elasticity, which goes up over time on average, has changed in similar ways for advantaged and disadvantaged groups. The regressions control for a cubic in age fully interacted with gender, and all measures of disadvantage. Interactions between mother's log BMI and measures of disadvantage are entered separately. The top panel shows the interaction of log of mothers' BMI with race/ethnicity; the second panel shows the interaction with the reference person's highest grade completed; the third panel shows the interaction with the income-to-poverty-line ratio. The results for the different waves of the NHANES are reported in the three columns.

Looking down the panels we see, in general, that for more disadvantaged children, the mother-child elasticity is smaller. For white non-Hispanic children in the third wave of the NHANES, for example, the mother-child elasticity is 0.211. For black children, on the other hand, that elasticity is 0.158, and this difference is statistically significant at the 10% level. Although the interaction between log of mothers' BMI and the education level of the reference person is statistically insignificant, the interaction with the income-to-poverty line ratio also suggests that the mother-child BMI elasticity is lower for disadvantaged families.

Table 5 uses the results from Table 4 to calculate the mother-child BMI elasticity for different groups. Doing this calculation makes clear that this elasticity has been growing more slowly over time for the disadvantaged. Consider a high school dropout with 10 years of education from NHANES I. The mother-child elasticity is 0.142, compared to 0.124 for a college graduate. By NHANES III, the mother-child elasticity for the college graduate has grown to 0.220, while that for the high school dropout is only 0.202. This result suggests that there is a greater role for the environment outside the family in explaining changes in BMI and obesity rates among disadvantaged children than among advantaged children.

C. Mother-Child BMI Elasticities by Quantile of Child's BMI

As mentioned in the introduction, an important characteristic of how BMI has changed over time is its distribution has become more unequal. Although BMI has increased for everyone, the BMI for the obese has increased more than for the median person. This suggests that there may be some people who are particularly susceptible to weight gain when the conditions are right, and in the last two decades, the conditions have been right.[12] Thus the impact of common genetic and environmental factors may be different for children who occupy different points in the BMI distribution. In particular, we would like to ensure that the lower mother-child BMI elasticity for disadvantaged kids that we find above is not simply due to the fact that disadvantaged kids are heavier and the mother-child BMI elasticity is lower among heavier kids, whether they are advantaged or disadvantaged.

Figures 3-5 plot the quantile regression estimates for the mother-child BMI elasticity for NHANES 1-3. We see that the elasticity is actually higher at higher quantiles of the BMI distribution, suggesting that for heavier children, the shared environmental-genetic component captured by mothers' BMI is more important in determining their BMI. This relationship seems to have gotten steeper over time. Note, of course, that children at the middle quantiles in NHANES 3 have BMIs that would have placed them farther up the quantile distribution in the earlier years. Thus these pictures are consistent with a story where the mother-child BMI elasticity is higher for a child who has reached a certain BMI. However, these results lend no support to the idea that the lower mother-child BMI elasticity for disadvantaged children is because disadvantaged children are heavier and all heavy children have lower mother-child BMI elasticities.

We also examined whether the quantile regressions look different by measures of disadvantage. Figures 6, 7, and 8 show the quantile regression results evaluated at high, medium, and low measures of the income-to-poverty line ratio for the three waves of the NHANES. The results suggest that the mother-child BMI elasticity is lower for disadvantaged children at all quantiles. The other measures of disadvantage (not shown) are consistent with these results.

V. Mother-Child Calorie Elasticities

Having seen that the intra-household correlation in BMI has increased over time, but more slowly for the disadvantaged, we now turn to looking more closely at intra-household correlations in eating patterns. Recall that in Table 2 we saw that over time the disadvantaged were making up ground in terms of calories from fruits and vegetables, and were no longer behind in terms of total calories. At the same time, the more advantaged were getting significantly more calories away from home. With NHANES 3, we have enough data to look at children matched to an adult household member.[13] The matched data looks very similar to the total data. Appendix Table 2 repeats the relevant panel of Table 2, and then replicates it using the matched data. Additionally, the more detailed food codes in NHANES 3 allow us to remove French fries and potato chips from the fruit and vegetable category, and to identify fast food consumption. The final columns, then, reflect these two additional food groups. Note that without French fries and chips, the effect of disadvantage on fruit and vegetable consumption

[12] Note that how this all works is far from settled science. Recent evidence suggests that the obese may have different body chemistry such that for a given number of calories ingested, their digestive tract can extract more calories for use (Weill Medical Center, 2007).

[13] We will be able to repeat this exercise using the latest NHANES as soon as we are allowed access to the household identifier.

becomes more important. Similarly, while the more advantaged do eat more fast food, the effect is much smaller than for the broader food-away-from-home category.

Having seen that the matched data is similar to the full data, we now estimated intra-household calorie elasticities in a manner identical to those calculated for BMI in Table 3. For each of the five food groups (i.e. total calories, fruit and vegetable calories, calories away from home, fruit and vegetable calories without fries and chips, and fast food calories), we regress the child's log(calories) on first the mother's log(calories), then the father's log (calories), and then both. The results are in Table 6. For total calories, the results are fairly similar to the BMI estimates. That is, both the mother and the father matter; estimates are similar whether the parents are included together or separately; and there is no significant difference between mother and father.

For the specific food groups, however, the mother and father elasticities are at least marginally significantly different, and the mother is always larger. The difference is especially noticeable in the more detailed food groupings. Thus, while mother is marginally different from father for all fruits and vegetables, once we remove French fries and chips there is a much more significant difference. When looking specifically at fast food, the maternal elasticity of 0.319 is twice the size of the paternal elasticity of 0.151. This finding is consistent with a story where fathers have opportunities to eat fast food that do not include their children -- for example, lunch on a work day. Overall, then, while it appears that both mother's and father's eating patterns influence children, mothers play the dominant role. Thus, as was the case with the BMI elasticities, we will just focus on the maternal elasticity when investigating the role of disadvantage.

Table 7 is parallel to the bottom panel of Table 4, in that it uses the income-to-poverty ratio as the measure of disadvantage, and interacts it with the maternal log(calorie) measure. Here, each column is a different food group. Looking first at column (1), we see that the elasticity of total calories is significantly larger for the more disadvantaged. This may be because, by this time period, advantaged mothers are more likely to work and work longer hours than disadvantaged mothers (Anderson et. al. (2003)). Advantaged mothers may be spending more time away from their children than disadvantaged mothers leading to a lower elasticity in calories consumed.

This does not, however, help explain the differences in mother-child BMI elastcities reported earlier. Recall that the BMI elasticity was significantly *smaller* for the more disadvantaged. Looking across the other columns, the interaction term is never significantly different from zero. Thus, we cannot explain the earlier BMI result as being due to a smaller relationship between the child's and the mother's eating patterns.

VI. Other Environmental Factors

Above we examine reported caloric in-take patterns for insight into the shared environment between mothers and their children that might affect their body mass. This is clearly a small subset of the complex environmental factors that affect body mass. One would clearly like information on calories expended as well as calories consumed. The measurement problems that attend collecting information on calories consumed are increased for calories expended – not only would one need information on the number of minutes spent running, for example, but the intensity of that activity. Carefully controlled medical studies are able to document how calories expended and consumed affect BMI, however, these necessarily give us

little insight into who chooses to participate in different caloric in-take and expenditure behavior and why they make those different decisions.

In order to explain differences in body mass between the advantaged and disadvantaged, many social science researchers have turned to documenting differences in the living environment that each group faces. We examined county business pattern data for 1980-1986 and 1988-1994 (years which roughly correspond to the second and third waves of the NHANES data – the period when we see an initial jump in children's obesity rates) in order to see whether the environments in which the disadvantaged live have changed differentially from the environments in which the advantaged live in ways that are likely to affect body mass.

There are several problems with this approach. First, the establishment definitions are course. Growth in the count of restaurants in an advantaged area may represent growth in establishments that cater to a health conscious crowd, in a disadvantaged area, it may represent growth in fast food restaurants. Thus, it is perhaps not surprising that we found no consistent pattern in changes in establishment types over time by county level measures of disadvantage.

A second problem is more fundamental, and would be a problem even if we had very detailed and accurate measures of establishment type linked to specific geographic areas. Ideally, we would like to examine whether an exogenous increase in concentration of fast food restaurants, for example, increases caloric in-take and increases body mass. Similarly, we would like to know whether an exogenous increase in recreational space, for example, increases exercise, and reduces weight. Without that exogenous variation, it is very hard to say whether fast food restaurants cause people to eat unhealthful foods, or whether they simply open near where they perceive their customers to live – e.g., obese individuals would likely consume fast

food whether or not there is one around the corner, but franchise owners in an attempt to get customers into their *particular* store may try to locate very close to the customers.

VI. Conclusion

Designing good policies to affect childhood obesity will require an understanding of how the environment that children face is related to their body mass. Although our attempts to measure changes in the food and exercise environments faced by advantaged and disadvantaged children were not fruitful, our earlier results suggest that they play an important role. If the only determinants of children's body mass were their genes and the environment they share with their parents, we would expect to find that increases in parent's BMI can go a long way toward explaining the increases we have seen in children's BMI over the last few decades. This is not the case. Based on our estimates of the mother-child BMI elasticity, the 4.1 percent increase in mothers' average BMI during the 1980s can explain between 20 to 30 percent of the 2.8 percent increase in children's average BMI. This suggests that there are factors in the environment that are unique to children that are important for determining their body mass.

Interestingly, the shared mother-child component of BMI became increasingly important over this time period, reflected in the increase in the mother-child BMI elasticity. This suggests an increasing role for the home (or neighborhood) environments that affect both parents' and children's body mass. However, this increase is smaller for disadvantaged children. This finding implies that policies that affect the food and exercise environment that is unique to children – in schools and day care settings, for example – are likely to have a bigger impact on the health outcomes of disadvantaged children. Policies to improve the healthfulness of food and

opportunities to exercise in schools and daycare may thus ameliorate some of the differences in obesity by disadvantage.

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Figure 1: Adult Obesity Rate, by Family Income

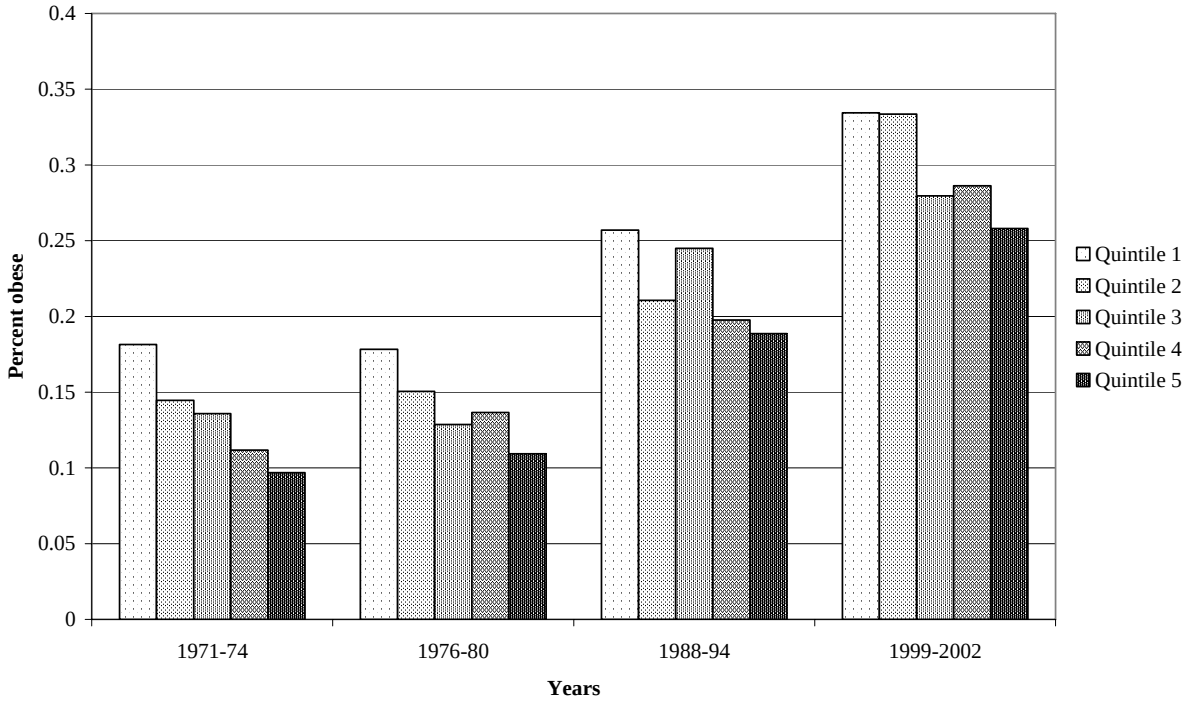
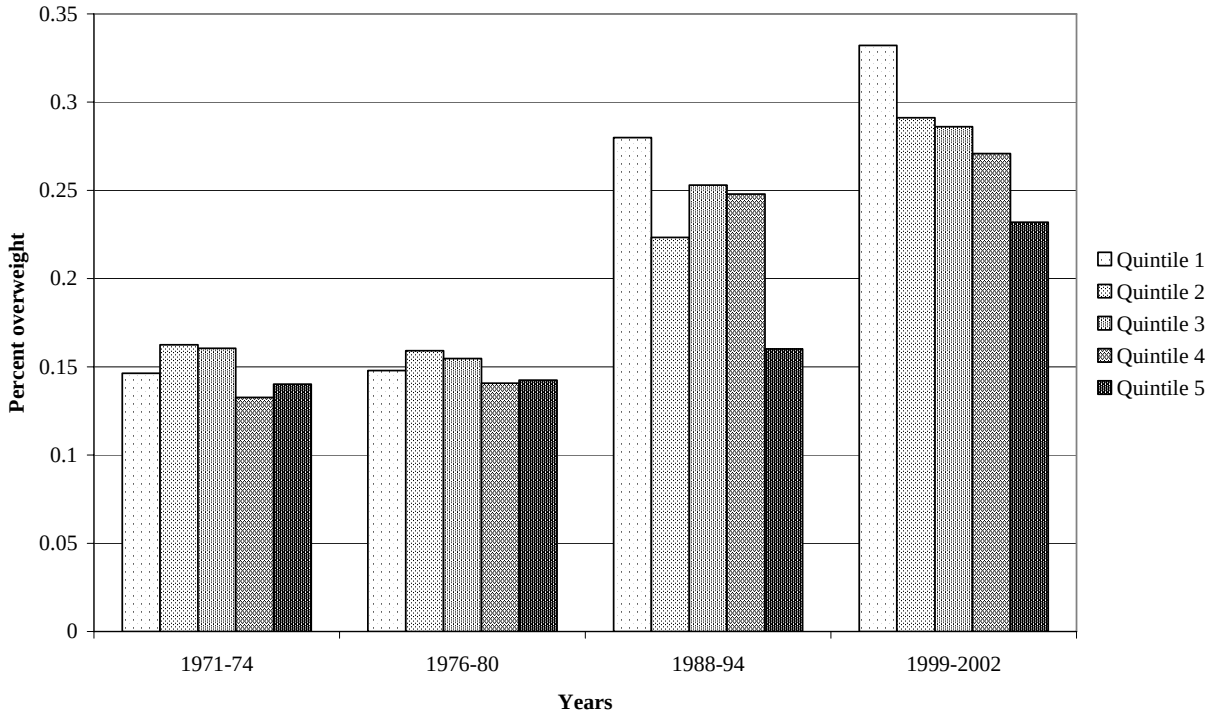


Figure 2: Children's (age 2-19) Overweight, by Family Income



Notes: Both figures are based on data from the NHANES.

Figure 3: NHANES 1 Mother-Child log(BMI) Relationship

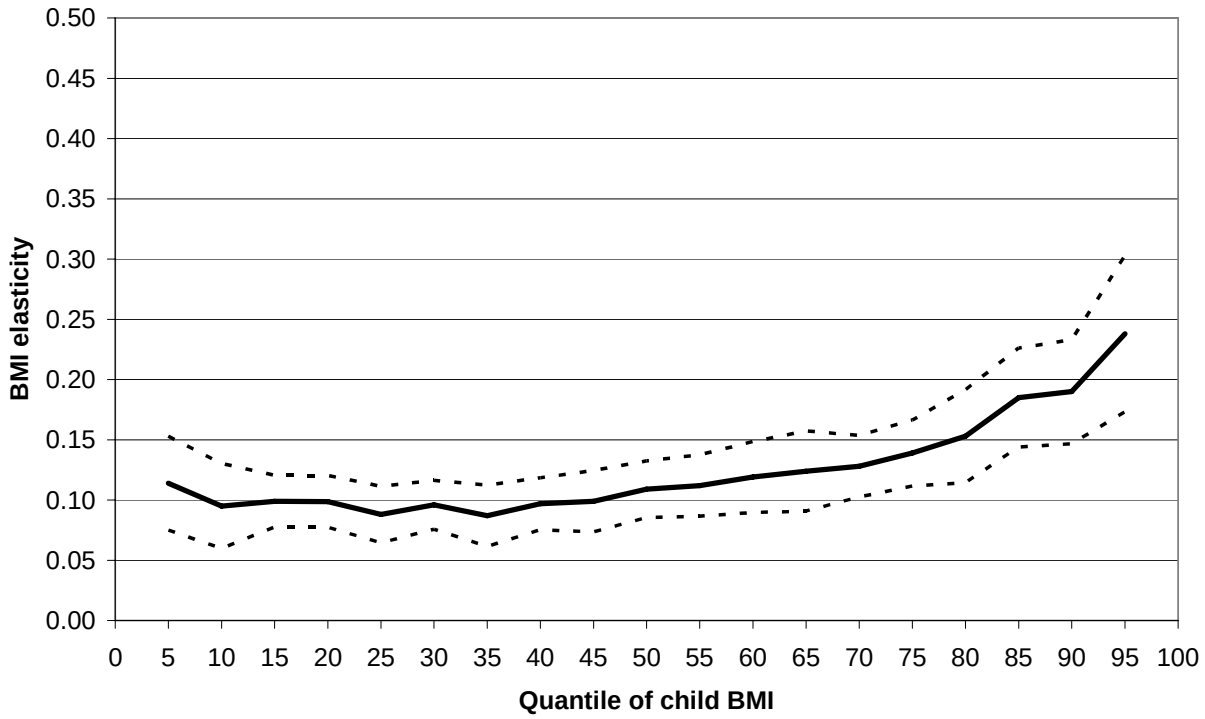


Figure 4: NHANES 2 Mother-Child log(BMI) Relationship

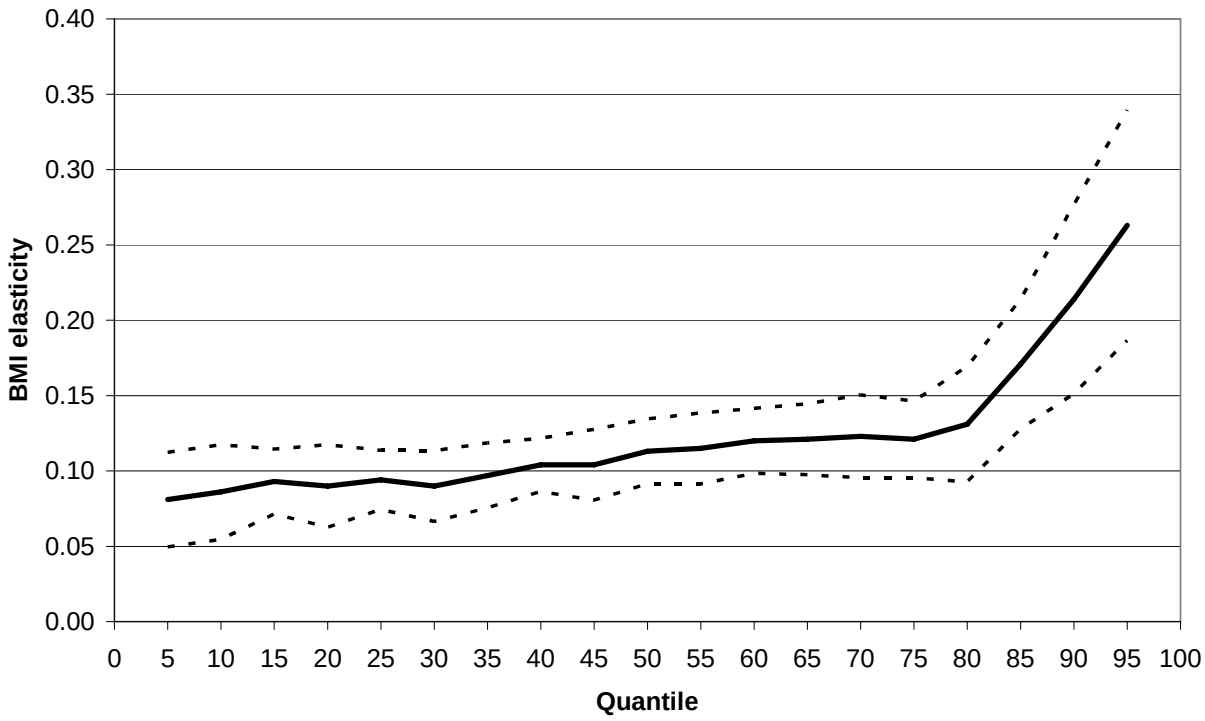


Figure 5: NHANES 3 Mother-Child log(BMI) Relationship

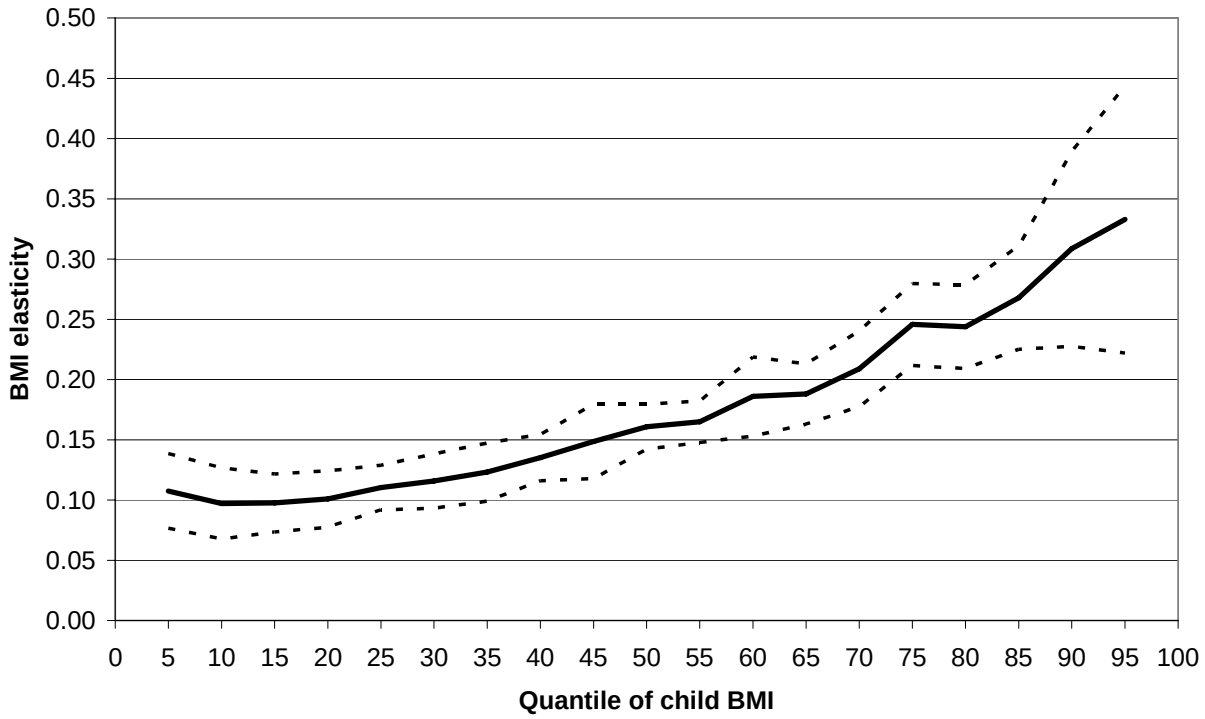


Figure 6: NHANES 1 Mother-Child, by Relative Poverty

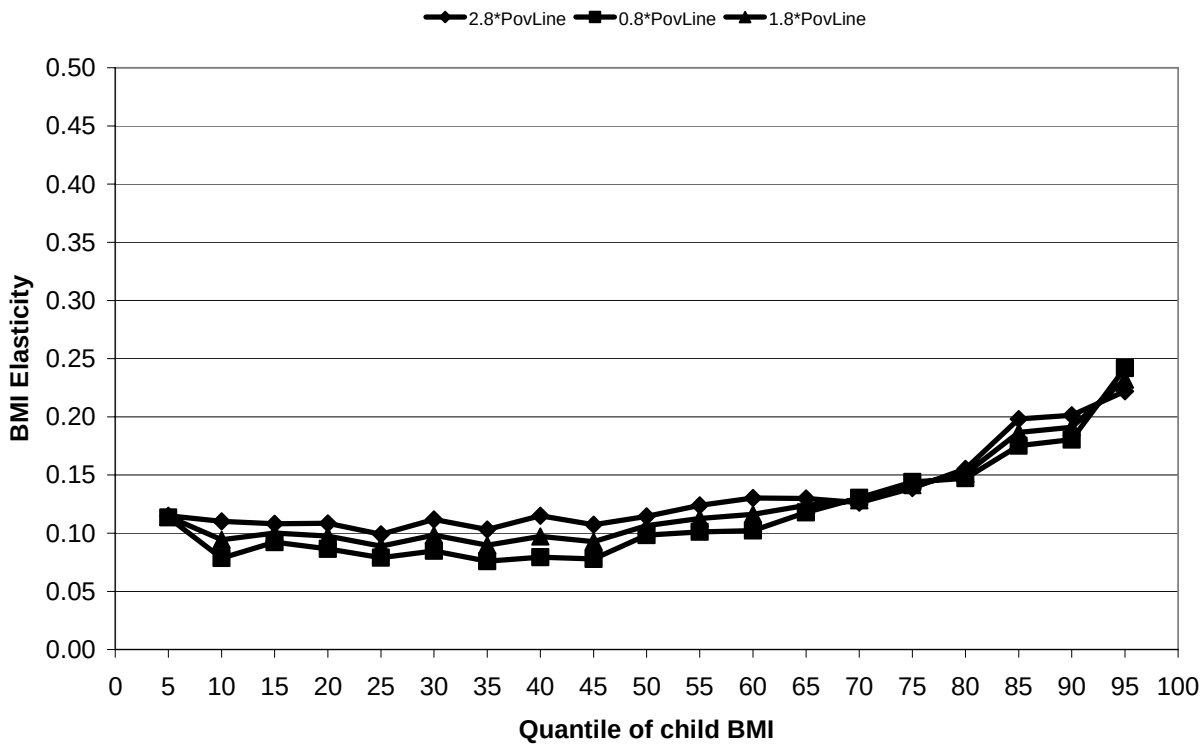


Figure 7: NHANES 2 Mother-Child, by Relative Poverty

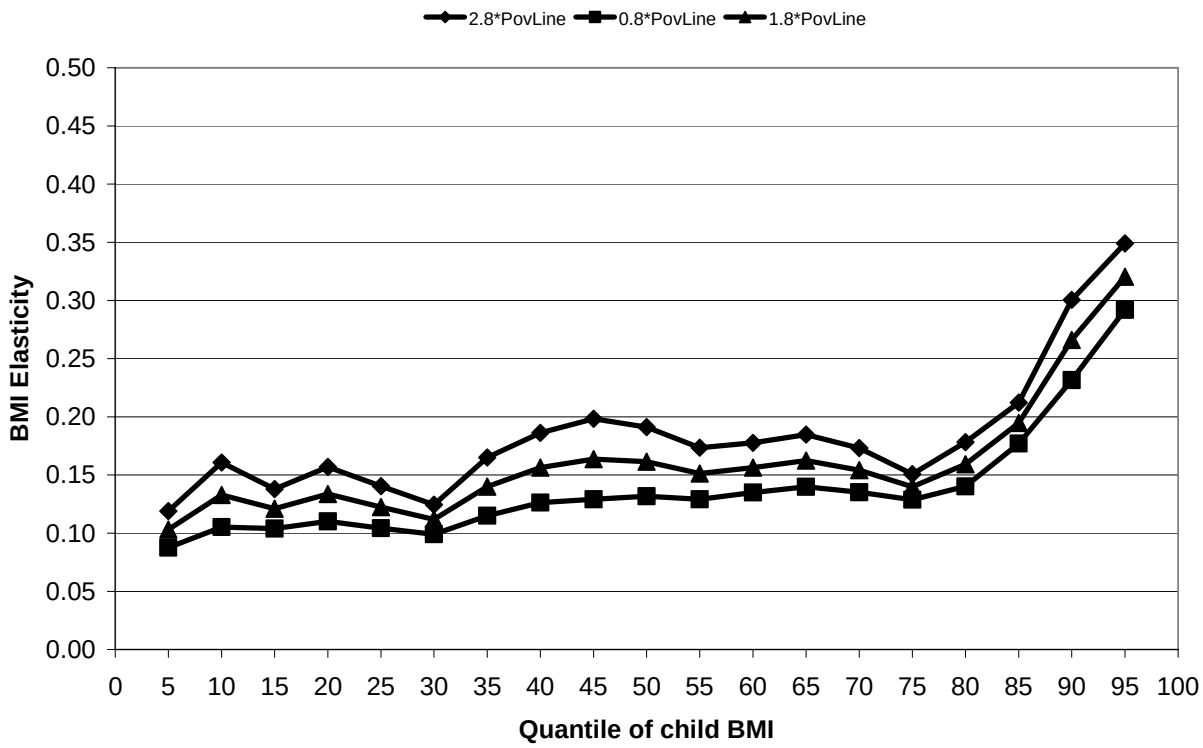


Figure 8: NHANES 3 Mother-Child, by Relative Poverty

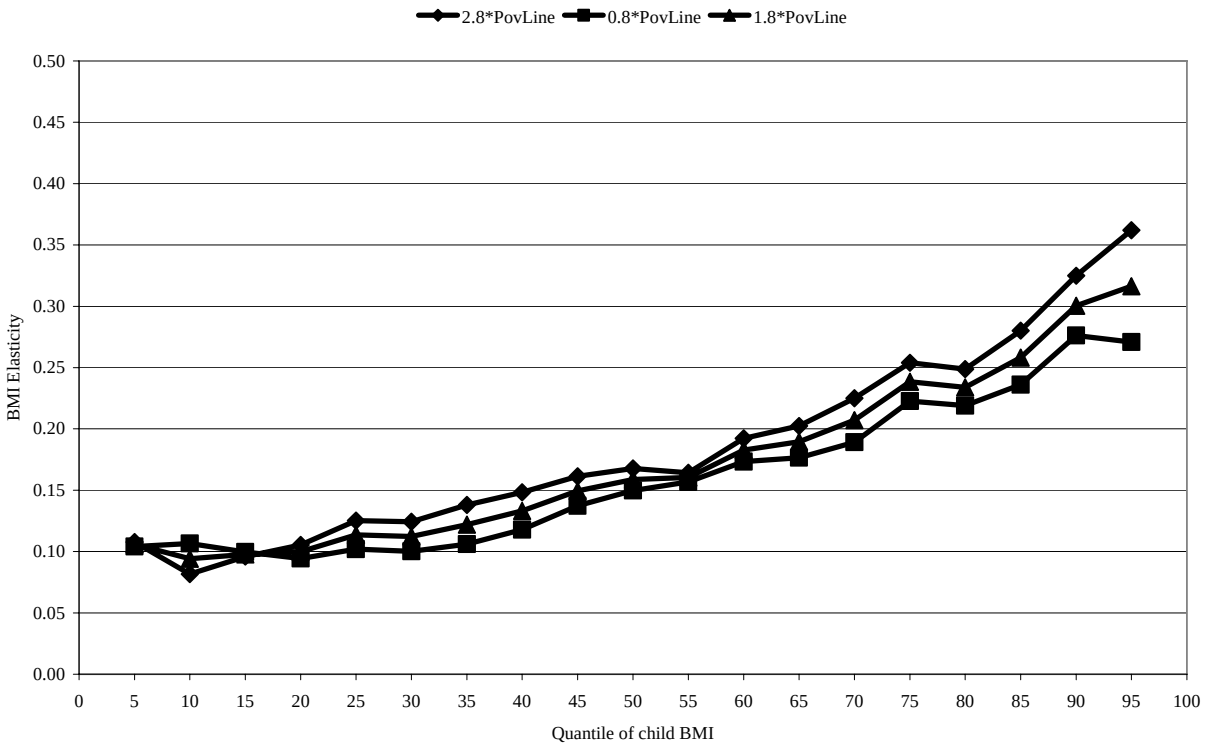


Table 1: Effect of Disadvantage on Children's log BMI

	(1)	(2)	(3)	(4)
Race on log BMI	**NHANES 1: 1971-75**	**NHANES 2: 1976-80**	**NHANES 3: 1988-94**	**NHANES 4: 1999-2004**
Black	-0.009	0.001	0.010	0.021
	(0.005)	(0.005)	(0.005)*	(0.006)**
Hispanic	0.016	0.034	0.039	0.035
	(0.007)*	(0.007)**	(0.006)**	(0.006)**
Other Non-white	0.010	-0.013	0.007	-0.002
	(0.019)	(0.012)	(0.006)	(0.009)
Observations	4092	4594	7124	5586
R-squared	0.16	0.18	0.17	0.20
Education on log BMI	**NHANES 1: 1971-75**	**NHANES 2: 1976-80**	**NHANES 3: 1988-94**	**NHANES 4: 1999-2004**
Highest grade for Reference Person	-0.002	-0.004	-0.004	N/A
	(0.001)**	(0.001)**	(0.001)**	
Observations	3992	4511	7029	
R-squared	0.16	0.18	0.17	
Poverty on log BMI	**NHANES 1: 1971-75**	**NHANES 2: 1976-80**	**NHANES 3: 1988-94**	**NHANES 4: 1999-2004**
Income/Poverty Line Ratio	0.001	-0.002	-0.006	-0.008
	(0.002)	(0.002)	(0.001)**	(0.001)**
Observations	4009	4466	6627	5142
R-squared	0.16	0.17	0.17	0.20
All 3 on log BMI	**NHANES 1: 1971-75**	**NHANES 2: 1976-80**	**NHANES 3: 1988-94**	**NHANES 4: 1999-2004**
Black	-0.008	-0.004	0.005	0.012
	(0.006)	(0.006)	(0.005)	(0.007)
Hispanic	0.008	0.026	0.026	0.026
	(0.008)	(0.008)**	(0.007)**	(0.006)**
Other Non-white	0.002	-0.016	0.000	-0.008
	(0.022)	(0.012)	(0.006)	(0.009)
Highest grade for Reference Person	-0.003	-0.005	-0.003	---
	(0.001)**	(0.001)**	(0.001)**	
Income/Poverty Line Ratio	0.004	0.005	-0.002	-0.006
	(0.002)*	(0.002)*	-0.002	(0.001)**
Observations	3918	4402	6555	5142
R-squared	0.16	0.19	0.17	0.20

Notes: All models also include a cubic in child's age fully interacted with gender. BMI is measured. Standard errors are in parentheses. Statistical significance level: *10%, **5%, ***1%. Sample is limited to children age 2-11 who have data for mother's reported BMI.

Table 2: Calorie Intake Among Children Age 2-11

	(1)	(2)	(3)
NHANES 1: 1971-75	log(Total Calories +1)	Log(Calories from Fruits & Vegetables +1)	Log(Calories eaten away from home +1)
Income/Poverty Line Ratio	0.006	0.080	0.002
	(0.004)	(0.016)**	(0.028)
Observations	4092	4092	4092
R-squared	0.11	0.01	0.09
NHANES 2: 1976-80	Log(Total Calories +1)	Log(Calories from Fruits & Vegetables +1)	Log(Calories eaten away from home +1)
Income/Poverty Line Ratio	0.011	0.081	0.065
	(0.005)*	(0.024)**	(0.042)
Observations	4466	4466	4466
R-squared	0.14	0.01	0.05
NHANES 3: 1988-94	ln(Total Calories + 1)	Ln(Calories from Fruits & Vegetables +1)	Ln(Calories eaten away from home +1)
Income/Poverty Line Ratio	-0.009	0.066	0.284
	(0.003)**	(4.45)**	(0.025)**
Observations	7046	7046	7046
R-squared	0.16	0.01	0.09
NHANES 4: 1999-2004	ln(Total Calories + 1)	Ln(Calories from Fruits & Vegetables +1)	Ln(Calories eaten away from home +1)
Income/Poverty Line Ratio	0.000	-0.026	0.357
	(0.004)	(0.019)	(0.034)**
Observations	3099	3099	3099
R-squared	0.11	0.02	0.08

Notes: Other covariates include a cubic in age fully interacted with gender.

Table 3: Intergenerational BMI Elasticity

NHANES 1: 1971-75	**(1)**	**(2)**	**(3)**
log Mother's BMI	0.142		0.131
	(0.010)**		(0.011)**
log Father's BMI		0.141	0.126
		(0.012)**	(0.012)**
Observations	3918	3609	3552
R-squared	0.20	0.19	0.22
F test: Mom=Dad			0.07
Prob > F			0.785
NHANES 2: 1976-80	**(1)**	**(2)**	**(3)**
log Mother's BMI	0.141		0.120
	(0.010)**		(0.011)**
log Father's BMI		0.180	0.152
		(0.014)**	(0.014)**
Observations	4402	4173	4116
R-squared	0.22	0.22	0.24
F test: Mom=Dad			2.69
Prob > F			0.101
NHANES 3: 1988-94	**(1)**	**(2)**	**(3)**
log Mother's BMI	0.206		0.178
	(0.009)**		(0.009)**
log Father's BMI		0.208	0.150
		(0.012)**	(0.012)**
Observations	6555	6016	5817
R-squared	0.24	0.22	0.26
F test: Mom=Dad			2.75
Prob > F			0.097

Notes: Dependent variable is the log of the child's measured BMI. Parental BMI data are reported. All models also control for race, highest grade completed by the household reference person, the household income to poverty ratio, and a cubic in child's age fully interacted with gender. Standard errors are in parentheses. Statistical significance level: *10%, ** 5%, ***1%.

Table 4: Interactions between Disadvatage and Mother's BMI

	(1)	(2)	(3)
Race on log BMI	**NHANES 1: 1971-75**	**NHANES 2: 1976-80**	**NHANES 3: 1988-94**
log Mother's BMI	0.155	0.146	0.211
	(0.012)**	(0.012)**	(0.011)**
Black	0.156	0.036	0.162
	(0.086)	(0.083)	(0.074)*
Hispanic	0.181	0.004	0.040
	(0.116)	(0.130)	(0.104)
Other race	-0.569	0.379	-0.155
	(0.462)	(0.214)	(0.088)
log Mother's BMI*Black	-0.054	-0.015	-0.053
	(0.027)*	(0.026)	(0.023)*
log Mother's BMI*Hispanic	-0.056	0.006	-0.010
	(0.036)	(0.041)	(0.032)
log Mother's BMI*Other race	0.180	-0.125	0.045
	(0.146)	(0.068)	(0.027)
Observations	3918	4402	6555
R-squared	0.20	0.22	0.24
Education on log BMI	**NHANES 1: 1971-75**	**NHANES 2: 1976-80**	**NHANES 3: 1988-94**
log Mother's BMI	0.172	0.177	0.172
	(0.030)**	(0.035)**	(0.036)**
Highest grade for Reference Person	0.008	0.006	-0.011
	(0.009)	(0.010)	(0.009)
log Mother's BMI*Highest grade	-0.003	-0.003	0.003
	(0.003)	(0.003)	(0.003)
Observations	3918	4402	6555
R-squared	0.20	0.22	0.24
Poverty on log BMI	**NHANES 1: 1971-75**	**NHANES 2: 1976-80**	**NHANES 3: 1988-94**
log Mother's BMI	0.119	0.101	0.171
	(0.019)**	(0.019)**	(0.015)**
Income/Poverty Line Ratio	-0.034	-0.065	-0.055
	(0.028)	(0.030)*	(0.019)**
log Mother's BMI* Income/Poverty Line	0.013	0.023	0.018
	(0.009)	(0.010)*	(0.006)**
Observations	3918	4402	6555
R-squared	0.20	0.22	0.24

Notes: Dependent variable is the log of the child's measured BMI. Parental BMI are reported. All models also control for all measures of disadvantage (race, highest grade completed by the household reference person, and household income-to-poverty ratio), and a cubic in child's age fully interacted with gender. Standard errors are in parenthesis. Statistical significance level: *10%, **5%, ***1%.

Table 5: Mother-Child BMI Elasticity by Group

	(1) NHANES 1: 1971-75	(2) NHANES 2: 1976-80	(3) NHANES 3: 1988-94
White	0.155	0.146	0.211
Black	0.101	0.131	0.158
Hispanic	0.336	0.150	0.251
Other race	-0.414	0.525	0.056
Reference Person's Education = 10	0.142	0.147	0.202
Reference Person's Education = 12	0.136	0.141	0.208
Reference Person's Education = 16	0.124	0.129	0.220
Income-to-Poverty Ratio = 0.8	0.129	0.119	0.185
Income-to-Poverty Ratio = 1.8	0.142	0.142	0.203
Income-to-Poverty Ratio = 2.8	0.155	0.165	0.221

Notes: Calculations based on elasticities reported in Table 4.

Table 6: Relationship between Parent and Child Calorie Intake

log(Total Calories)			
log(Mom's total calories)	0.101 (0.014)**		0.101 (0.019)**
log(Dad's total calories)		0.147 (0.022)**	0.131 (0.022)**
Observations	3342	1859	1859
R-squared	0.17	0.18	0.19
F test: Mom=Dad			0.97
Prob > F			0.324
log(Calories Eaten Away from Home)			
log(Mom's calories away from home)	0.288 (0.015)**		0.202 (0.021)**
log(Dad's calories away from home)		0.179 (0.024)**	0.145 (0.024)**
Observations	3342	1859	1859
R-squared	0.16	0.11	0.15
F test: Mom=Dad			2.81
Prob > F			0.094
log(Calories from Fruits & Vegetables)			
log(Mom's fruit/veg calories)	0.246 (0.018)**		0.248 (0.024)**
log(Dad's fruit/veg calories)		0.237 (0.024)**	0.179 (0.024)**
Observations	3342	1859	1859
R-squared	0.07	0.08	0.13
F test: Mom=Dad			3.49
Prob > F			0.062
log(Calories from Fruits & Vegetables, Less French Fries)			
log(Mom's fruit/veg calories, no fries)	0.263 (0.016)**		0.270 (0.022)**
log(Dad's fruit/veg calories, no fries)		0.229 (0.022)**	0.146 (0.023)**
Observations	3342	1859	1859
R-squared	0.09	0.09	0.16
F test: Mom=Dad			11.53
Prob > F			0.001
ln(Calories from Fast Food)			
log(Mom's fast food calories)	0.375 (0.014)**		0.319 (0.020)**
log(Dad's fast food calories)		0.229 (0.018)**	0.151 (0.018)**
Observations	3342	1859	1859
R-squared	0.19	0.1	0.21
F test: Mom=Dad			31.18
Prob > F			0.000

Note: Data are for the matched NHANES 3 (1988-94) sample. Other covariates include a cubic in age fully interacted with gender.

Table 7: Relationship between Calories, Disadvantage and Mother's Calories

	(1)	(2)	(3)	(4)	(5)
	log (Total Calories + 1)	log (Calories from Fruits & Vegetables +1)	log (Calories eaten away from home +1)	log (Calories from fruit/veg, no fries +1)	log (Calories from fast food +1)
log Mother's calories	0.162	0.224	0.310	0.267	0.360
	(0.026)**	(0.031)**	(0.027)**	(0.028)**	(0.026)**
log Mother's calorie*	-0.03	0.011	-0.011	-0.002	0.007
Income/Poverty Line Ratio	(0.011)**	(0.013)	(0.011)	(0.011)	(0.010)
Observations	3342	3342	3342	3342	3342
R-squared	0.17	0.07	0.16	0.09	0.19

Appendix Table 1: Summary Statistics

	(1)	(2)	(3)	(4)
	NHANES 1: 1971-75	**NHANES 2: 1976-80**	**NHANES 3: 1988-94**	**NHANES 4: 1999-2004**
BMI	16.41	16.58	17.05	17.62
	(2.29)	(2.61)	(3.02)	(3.53)
Mother's BMI	24.14	23.93	24.90	N/A
	(4.96)	(4.91)	(5.54)	
Father's BMI	28.68	25.62	26.12	N/A
	(5.30)	(3.65)	(4.05)	
Black	0.14	0.15	0.16	0.15
	(0.34)	(0.36)	(0.36)	(0.36)
Hispanic	0.07	0.08	0.08	0.20
	(0.25)	(0.27)	(0.28)	(0.40)
Other race	0.01	0.03	0.10	0.06
	(0.10)	(0.16)	(0.30)	(0.24)
Female	0.49	0.49	0.49	0.49
	(0.50)	(0.50)	(0.50)	(0.50)
Highest grade of reference person	11.54	11.87	12.60	
	(3.16)	(3.25)	(3.05)	
Income/Poverty line ratio	2.12	1.99	2.21	2.30
	(1.22)	(1.09)	(1.42)	(1.56)
Observations	4092	4594	7124	5586

Note: Standard deviations in parentheses

Appendix Table 2: Comparing Reported and Matched NHANES 3 Samples

	(1)	(2)	(3)	(4)	(5)
NHANES III: Overall Sample	log (Total Calories + 1)	log (Calories from Fruits & Vegetables +1)	log (Calories eaten away from home +1)	log (Calories from fruit/veg, no fries +1)	log (Calories from fast food +1)
Income/Poverty Line Ratio	-0.009 (0.003)**	0.066 (4.45)**	0.284 (0.025)**	0.117 (0.016)**	0.035 (0.017)*
Observations	7046	7046	7046	7046	7046
R-squared	0.16	0.01	0.09	0.01	0.00
NHANES III: Matched Sample	log (Total Calories + 1)	log (Calories from Fruits & Vegetables +1)	log (Calories eaten away from home +1)	log (Calories from fruit/veg, no fries +1)	log (Calories from fast food +1)
Income/Poverty Line Ratio	-0.002 (0.005)	0.039 (0.023)	0.251 (0.037)**	0.081 (0.024)**	0.044 (0.026)
Observations	3365	3365	3365	3365	3365
R-squared	0.15	0.00	0.07	0.01	0.00