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# **Economic, Environmental, and Endowment Effects on Childhood Obesity**

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# ABSTRACT

This paper examines factors associated with the childhood obesity phenomenon in the U.S. A national longitudinal dataset “Early Childhood Longitudinal Study, Kindergarten-Fifth Grade” (ECLS-K) that has data for 12,719 children from fall 1998 (Kindergarten year) through spring 2004 (Fifth grade) is used. Two econometric models, a mixed-effects ordered Logit and a random-effects Tobit, are used to predict obesity status and the extent to which a child is overweight (the excess level of a child’s Body Mass Index). The results show that the more time parents spend working and certain non-parental care sources such as at-home childcare (as opposed to childcare at centers) are statistically significant in predicting the likelihood of childhood obesity and their level of excess weight. Endowment factors such as child’s birth weight and race, and other demographic factors such as parents’ social economic status, family structure, and family size are strongly correlated with these two outcomes. Environmental factors such as bed time, computer use, and physical education programs at school are negatively correlated with the level of excess weight but not statistically significant in predicting the probability of being overweight in children. The results of this study will be useful for educators, parents, and policy makers.

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## **1. Introduction**

According to the World Health Organization (WHO), there are over one billion overweight adults worldwide, with more than thirty percent of those being obese (2006). Overweight and obese adults are defined as having a body mass index (BMI)<sup>1</sup> over 25 and 30, respectively. For children and adolescents, these terms are defined as having a BMI above the 85<sup>th</sup> and 95<sup>th</sup> percentiles (of growth) for a child's age and sex group. Obesity rates have risen three-fold or more since 1980 in both developed and developing areas of the world. Overweight rates in U.S. children and adolescents 2-19 years of age have more than tripled, from 5 percent in the 1970's to 17.1 percent in 2003-04 (CDC, 2006).

Childhood obesity is either directly or indirectly associated with a variety of health problems such as sleep apnea, type II diabetes, asthma, mental health, and most importantly, greater risk of becoming obese adults (HHS, 2004). The escalating rate of obesity highlights the importance of understanding its causes and consequences. However, while the health, social, and economic costs of obesity are apparent, the mechanisms underlying this problem are less obvious. It is widely believed that parents play a central role in their children's food choices and activities, affecting the nutritional and physical health experienced by those children. To achieve healthy outcomes, parents have to devote sufficient time and income to care for their children.

Given the assumption that both nature and nurture factors affect childhood obesity, this paper seeks to understand the influence of parents' time constraints on childhood obesity, using Becker's (1965) economic framework of a household production model (HPM). Particularly, it explores the relationship between childhood obesity and the quantity and quality of the time that parents have for

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<sup>1</sup> BMI is defined as the weight (in kilograms) divided by height (in meters) squared. Equivalently, the weight (in pounds) divided by height (in inches) squared and multiply the answer by 703.

their children, controlling for certain environmental and endowment factors. In other words, it investigates the effect of parents' time input in a household production of a healthy output, i.e. a not overweight child.

The data analyzed in this study were from the U.S. Department of Education's Early Childhood Longitudinal Study, Kindergarten class of 1998-99 (ECLS-K), merged with two other sets of data: *monthly housing cost for homeowners with mortgage* from the US Census and *weekly average wages* from the Bureau of Labor Statistics<sup>2</sup>.

The ECLS-K project is an ongoing study that collects data on a cohort of children's early school experiences beginning with kindergarten and following these children through high school. The ECLS-K is the first national survey on public and private kindergarten programs and children who attend them. The newest round of data available is through 5<sup>th</sup> grade in the year 2004. This dataset provides a wide range of data needed to understand children's health, early learning, development, and education experiences. Data is collected for the child, the child's parents/guardians, teachers, and schools through child direct assessment, home and school interviews.

The ECLS-K survey used a multi-stage probability sampling design. A nationally representative sample of approximately 22,000 children enrolled in 1,000 kindergarten programs during the 1998-99 school year were selected for participation in the study. In this base year, the primary sampling units (PSUs) were geographic areas consisting of counties or groups of counties

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<sup>2</sup> This is done by using home-based census tracts available from the ECLS-K restricted dataset, grouped together at the county-level and/or state-levels in order to merge with available information from the US Census Bureau and the Bureau of Labor Statistics. Most of *monthly cost of homeowner with mortgage* data is available at state-level, and *wage* data is available for over 300 largest counties or 100 metropolitan areas. Therefore, state-level or metropolitan-level information is used for counties that do not have data.

selected with probability proportional to size (PPS) where size was the number of 5-year-olds. The second-stage units were schools within sampled PSUs. The third and final stage units were students within schools. The sample consists of children from different racial-ethnic and socioeconomic backgrounds and includes an oversample of Asian, and private school kindergartens.

This study estimates reduced-form equations for the health status, for a measure of body mass index (BMI), of U.S. children in the age range of five to twelve. There is a consensus for using age- and gender-specific BMI scores or BMI percentile to study adiposity changes in growing children, particularly with longitudinal studies (Cole et al, 2005; Berkey and Colditz, 2006).

Traditional methods for analyzing longitudinal data have been pooled ordinary least square (OLS), random-effects, fixed-effects, or first differencing (Wooldridge, 2002). A recent development of new methods to incorporate the hierarchical structure of data (e.g. nested structure of students within a class or school) includes mixed-effects models (also called hierarchical linear models by Raudenbush and Bryk, 1992) and generalized linear latent and mixed models (GLLAMM) developed by Rabe-Hesketh and Skrondal (2005).

In this study, two estimating models are utilized to take full advantage of the hierarchical structure and longitudinal data. An ordered Logit model is estimated with the GLLAMM specification to predict the probability of a child being overweight or obese. A random-effects Tobit model is used to examine factors associated with increased excess weight once a child is already classified as overweight. In the Logit model, the BMI for a given child across the various survey rounds were classified into three categories which are adapted from the Centers for Disease Control and Prevention's (CDC) weight status categorization for children. The terms "normal", "overweight", and "obese" are used to indicate children with a BMI less than the 85<sup>th</sup> percentile,

between the 85<sup>th</sup> and 95<sup>th</sup>, and above the 95<sup>th</sup> percentile in this study. In the Tobit model, the actual measure of BMI is used as the dependent variable, after accounting for the age- and gender-specific cut-off point that distinguish overweight and obese children from normal weight ones.

There are several advantages of these new analytic methods. In estimating multilevel models, it is essential to estimate the variance component because there is an assumption that the errors within each randomly sampled cluster are likely to be correlated. With the hierarchical nature of the dataset used in this study, it is important to incorporate random effects into the specification of models estimated (Hox and Kreft, 1994). The fixed-effects term refers to the overall expected effect of households' and students' demographics and parent's time on children's BMI and obesity status (normal, overweight, or obese). The random-effects give information on whether or not these effects differ between children (level-2) and between schools (level-3)<sup>3</sup>. In addition, GLLAMM is a class of multilevel latent variable models where a latent variable (common factors or random effects) can be assumed to be discrete or to have a multivariate normal distribution. It is generalized in the sense that it can incorporate different types of response model (e.g. continuous, ordinal, rankings, or mixed responses), with latent variables that can vary at different levels of a hierarchical/multilevel dataset.

## ***2. Analytical framework***

First an application of the household production model (HPM) theory is summarized. Following is a sketch of the derivation of reduced-form equations for weight status from the theoretical model. The two estimating models applied to the longitudinal data are then discussed.

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<sup>3</sup> Level 1 is defined as within students across data collection rounds (over time).



## 2.1 Theoretical model

The standard economic framework for analyzing children's outcomes such as health, nutrition intakes, and educational attainment has utilized the HPM model, which incorporates the time dimension into the full budget constraint that households face when maximizing utility. The economic theories of household allocation and children's outcomes can be categorized into two major strands, unitary and collective/bargaining model<sup>4</sup>.

In the context of this study, we assume a unitary model is sufficient to model the effect of parental work time on childhood obesity for three reasons. First, the traditional conceptualization of separate roles for each parent in a household has diminished over the last several decades in the U.S. Although the gap between the time employed men and women spend in household tasks and childcare still exists, it has decreased dramatically and experts predict convergence (Bond et al, 1998). Therefore, a households' decision on individual time and resource allocation between parents is viewed not as important as between parents and children within a household. Secondly, unlike developing countries where research has shown mother's education and work for pay have a substantial impact on children's health, U.S. parents (male and female) are assumed to share a common view of what is a "healthy weight" and what is not. Thirdly, the age group of interest is 5-11, which could be viewed as "passive children" since they still mostly depend on their parents for decisions about food consumption and physical activities, both of which have a direct effect on BMI<sup>5</sup>.

A household maximizes utility  $U[H, X, t_i; j]$  which is a function of family members' health  $H$ , consumption of market goods and services  $X$ , and leisure  $t_i$ , subject to a budget constraint

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<sup>4</sup> See Schultz (1999) for a more detailed review of the literature on the development of household models.

<sup>5</sup> See Bherman et al (2005) for a thorough discussion and definition

$pX = wt_w + n$  where  $p$  is exogenous prices for the market basket of goods  $X$ ; a time constraint

$T = t_l + t_w = t_z + t_H + t_w$  where time is divided between leisure and market work; leisure is the sum of time used to produce health outcome  $t_H$  and other household-produced goods  $t_z$ . The household production functions are  $Z = f[X, t_z]$  and  $H^i = h[Z, t_H; f]$  where  $f$  is a child's characteristics.

In this framework, parents' time and income are pooled together in the full budget constraint in maximizing their household utility, which is also characterized by household preferences  $j$ .

Specifically, total available time is optimally allocated across outside work, home production, and leisure, which in this case is assumed to not be separable from the home production function<sup>6</sup>. The solutions derived from this utility maximizing problem are demand functions for the market goods  $X^*[p, w, I; j]$  and time used to produce healthy children  $t_H^*[w, p, T, j, f]$ . By substituting these into the health production function, we can derive an equation for health production

$H^i = f[Z^*, t_H^*; j, f]$ . Therefore, household total time and income is important in estimating the health outcomes for children in a unitary household model. This framework has been adapted for estimating a wide range of children's outcomes (Rosenzweig and Schultz, 1983; Senauer and Gracia, 1991; Variyam et al, 1999).

## 2.2 Reduced form estimating functions

The reduced-form health demand function resulting from the above theoretical framework has the general form  $H = f[w, p, I | X, e]$  where  $H$  is the weight status (either BMI scores or weight status categories),  $p$  is a vector of exogenous prices,  $w$  is wage rate,  $I$  is the household full income,  $X$  is a

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<sup>6</sup> That is, we assume without loss of generality that there is a substitution effect between housework, leisure, and childcare in parental time at home. In other words, we focus on the relationship between time used to work for pay and time used for home production, rather than elements of time used for home production. Besides, it is subjective to identify certain elements of childcare, particularly secondary childcare activities such as playing with a child as being "work" or "pleasure".

vector of observable household and child's characteristics, and  $e$  is a random variable representing unobserved household and child effects. Theoretically, we can also utilize the optimal results from the unitary household production framework to evaluate the health production function  $H^* = f[Z^*, t_z^*; j, f]$  where  $H^*$  is the weight status;  $Z^*$  - a vector of home-produced goods – a solution of the utility maximizing problem described above;  $t_z^*$  is the optimal time used to produce  $Z$ ;  $j$  is a vector of household factors, and  $f$  is child characteristics. Both of these functions are evaluated in this study.

## 2.3 Econometric estimating models

There are two estimating methods in this study; mixed-effects ordered Logit and random-effects Tobit. We chose order Logit (with three categories of BMI) over the mixed model (with continuous BMI as dependent variable) for two reasons. First, although the underlying BMI is continuous, what matters most is whether children are below or above a certain level of BMI because it indicates whether they are healthy or not. Secondly, in terms of prevention policies, excess weight gain is a more important factor compared to incremental weight gains, which might coincide with growth rates, even after we adjust for age and gender. Therefore, a primary obesity-prevention approach emphasizes efforts that can help normal-weight children maintain that weight and help overweight children prevent further weight gain (Koplan et al, 2005). In addition, a Tobit model is used precisely for the latter reason, to evaluate factors that contribute to the excess weight gain in overweight children.

### 2.3.1 Mixed-Effect Ordered Logit using GLLAMM

The estimating equation is as follows

$$\text{Logit}\{\Pr(y_{itk} = (3\text{categories}) \mid x_{itk}, V_{ik}^{(2)}, V_k^{(3)})\} = b_0 + \beta x_{itk} + V_{ik}^{(2)} + V_k^{(3)} + e_{itk}$$

$$\text{where } y_{itk} = \begin{cases} 0 & \text{if } y_{itk}^* = \text{"normal"} \\ 1 & \text{if } y_{itk}^* = \text{"overweight"} \\ 2 & \text{if } y_{itk}^* = \text{"obese"} \end{cases} \quad \text{for } i^{\text{th}} \text{ child at } t^{\text{th}} \text{ round in } k^{\text{th}} \text{ school}$$

$e_{ik}$  has a logistic distribution with variance  $p^2 / 3$

$V_{ik}^{(2)} | x_{itk}, V_k^{(3)} \sim N(0, \mathbf{Y}^{(2)})$ : a random intercept varying over students (level 2)

$V_k^{(3)} | x_{itk} \sim N(0, \mathbf{Y}^{(3)})$ : a random intercept varying over school (level 3)

Assume that  $V_{ik}^{(2)}$  and  $V_k^{(3)}$  are independent from each other and across schools, and  $V_{ik}^{(2)}$  is independent across students.

### 2.3.2 Tobit

The stochastic model underlying Tobit may be expressed as follows:

$$BMI_i = \text{Max} \left( L, b_0 + \sum_{i=1}^n b_i x_i + e_i \right)$$

Where  $BMI_i$  is the continuous BMI measure for child  $i^{\text{th}}$ ;  $L$  is the limit observation on  $BMI_i$  being the cut-off point between normal weight and overweight children; and  $X_i$  is a set of vectors that include socio-economic, environmental, and endowment factors. Calculations in the Tobit model assume a Tobit index  $I$  where  $I = X' b$ . If  $I$  falls below a threshold level  $I^*$  (85<sup>th</sup> percentile of the weight for age growth chart), the weight status of a child is considered to be zero, that is, the child is not overweight. Therefore, the expected value of  $BMI_i$ ,  $E(BMI_i)$ , is defined as:

$$E(BMI_i) = 0 \text{ if } I < I^*$$

$$E(BMI_i) = I - I^* \geq 0 \text{ if } I \geq I^*$$

The expected value of  $BMI_i$  is the average value of BMI for a child, weighted by the probability that the  $i^{\text{th}}$  child is overweight. The effect of a change in any independent variable on  $E(BMI_i)$  can be

determined as  $\frac{\partial E(BMI_i)}{\partial x_i} = P \times \hat{b}_i$  where  $P$  is the probability that  $BMI_i > 85^{\text{th}}$ , and  $\hat{b}_i$  is the non-

normalized estimated coefficient.

The probability of a child being classified as overweight is  $\text{Prob}\{Y_i > 85^{\text{th}} | b_i x_i\} = F\left(\frac{x' b}{s}\right)$ .

### **3. Data and Variables**

This section describes the set of variables used in the empirical analysis. Descriptive statistics are given in table 1, with a description of each variable.

Table 1 reports the means of the quantities and qualities of parental time, environmental, and endowment factors for each category of child's BMI. Columns (1) and (2) list names and description of variables. Columns (3) to (6) display the mean and standard deviations of all variables in the sample used in this study, overall and by categories of normal, overweight, and obese. The last two columns (7) and (8) describe the significance of pair-wise t-tests between normal and overweight, and between normal and obese children, respectively.

These descriptive statistics are shown for the sample used in all regressions in this study, which has 24,512 observations of children over the four rounds of data. For sample attritions which include non-response and change in eligibility status over time, see Tourangeau et al (2006) for more details on data collection procedures and comparative statistics.

#### **3.1 Dependent variables**

The composite variable BMI from ECLS-K5 longitudinal dataset is used as a dependent variable for both models. Although the height and weight components of this composite variable were measured directly by assessors, data entry and coding mistakes might still occur, resulting in some unreasonable numbers such as under 10 or over 40 for children in the age group between five and twelve. Therefore, 30 observations with BMI less than 10 or over 40 were omitted from all four rounds of data. This study uses the terms “normal”, “overweight”, and “obese” to indicate children with BMI less than 85<sup>th</sup> percentile, between 85<sup>th</sup> and 95<sup>th</sup>, and above 95<sup>th</sup> percentile, respectively<sup>7</sup>. Therefore, there are three

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<sup>7</sup> According to the Centers for Disease Control and Prevention's weight status categorization, children with BMI that rank less than 5<sup>th</sup> percentile of the growth chart is considered “underweight”; between 5<sup>th</sup> and 85<sup>th</sup> percentile BMI are “healthy weight”; between 85<sup>th</sup> and 95<sup>th</sup> percentile are “at risk of overweight”; and above 95<sup>th</sup> percentile are overweight.

categories of weights that are used in the ordered Logit model. The cut off points are age- and gender-specific. In the Tobit model, BMI is left-censored for the “normal” weight category (e.g. while reported BMI measures are used for “overweight” and “obese” children.

**Table 1: Variables and Descriptive Statistics with Pair-wise t-test**

		(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Variable	Definition	Mean/Standard Deviation				Normal vs. OW		Normal vs. OB	
		Overall	Normal	Overweight	Obese				
ConBMI	Continuous BMI	17.899 (3.73)	15.998 (1.46)	19.268 (1.78)	24.108 (3.95)	***		***	
P1HRS	Person 1 total working hours	35.775 (12.67)	35.242 (13.01)	36.583 (12.03)	37.049 (11.82)	***		***	
P2HRS	Person 2 total working hours	46.765 (10.81)	46.859 (10.79)	46.723 (11.09)	46.411 (10.59)	-		*	
CCHOME	Childcare at child's home	0.103 (0.31)	0.099 (0.29)	0.104 (0.31)	0.119 (0.32)	-		***	
CCOHOME	Childcare at someone else's home	0.144 (0.351)	0.134 (0.34)	0.165 (0.37)	0.161 (0.37)	***		***	
CCCENTER	Childcare at centers	0.148 (0.36)	0.152 (0.36)	0.145 (0.35)	0.133 (0.34)	-		***	
CCOTHER	Other arrangements of childcare	0.017 (0.13)	0.015 (0.12)	0.018 (0.13)	0.021 (0.14)	-		***	
WOKEARLY	Mother work between childbirth and	0.763 (0.76)	0.758 (0.23)	0.777 (0.42)	0.772 (0.42)	***		*	
WARMCL	Frequency of warm close time together	2.657 (0.53)	2.662 (0.53)	2.658 (0.53)	2.636 (0.56)	-		***	
EVENG	Number of evening meals together	5.632 (1.72)	5.645 (1.71)	5.637 (1.71)	5.579 (1.78)	-		*	
PCHINVOL	Index of parent-child involvement	15.001 (4.15)	15.037 (4.17)	15.042 (4.09)	14.839 (4.11)	-		***	
BothPA	Live with both biological parents	0.815 (0.39)	0.827 (0.38)	0.809 (0.39)	0.776 (0.42)	***		***	
SingleM	Live with biological mother only	0.161 (0.37)	0.121 (0.33)	0.141 (0.35)	0.169 (0.37)	***		***	
SingleD	Live with biological father only	0.01 (0.08)	0.006 (0.07)	0.006 (0.07)	0.007 (0.08)	-		-	
OtherPA	Live with adopted parent(s) or guardian(s)	0.017 (0.13)	0.016 (0.13)	0.013 (0.11)	0.014 (0.12)	-		-	
NUMSIB	Number of siblings child has	1.505 (1.08)	1.537 (1.09)	1.476 (1.06)	1.409 (1.05)	***		***	
PARED	Parents' education	2.098 (0.89)	2.153 (0.88)	2.068 (0.91)	1.914 (0.92)	***		***	
IN15C	Household income, <\$15,000/yr	0.089 (0.28)	0.082 (0.27)	0.088 (0.28)	0.112 (0.31)	*		***	
IN30C	Household income, \$15,001-\$30,000	0.161 (0.37)	0.144 (0.35)	0.171 (0.37)	0.216 (0.41)	***		***	
IN50C	Household income, \$30,001-\$50,000	0.244 (0.43)	0.241 (0.41)	0.245 (0.43)	0.259 (0.44)	-		***	
IN75C	Household income, \$50,001-\$75,000	0.214 (0.41)	0.218 (0.41)	0.218 (0.41)	0.195 (0.39)	-		***	

INCHIGH	Household income higher than \$75,000	0.262 (0.44)	0.316 (0.46)	0.277 0.45	0.218 (0.41)	***	***
PAHEALTH	Parents' health	1.137 (0.89)	1.079 (0.88)	1.182 (0.91)	1.323 (0.93)	***	***
FSSTAT	Food security status, have food problem	0.065 (0.23)	0.059 (0.22)	0.062 (0.23)	0.088 (0.27)	-	***
DOC2VIS	Visit doctor for routine care within one year	0.863 (0.34)	0.861 (0.35)	0.868 (0.34)	0.869 (0.34)	*	*
SLUNCH	Child receive complete lunch from school	0.700 (0.46)	0.669 (0.47)	0.703 (0.45)	0.757 (0.43)	***	***
BEDTIME	Child goes to bed after 10pm	0.044 (0.21)	0.041 (0.19)	0.048 (0.21)	0.055 (0.23)	**	***
HOMECEM	Has a home computer	0.766 (0.42)	0.775 (0.42)	0.759 (0.42)	0.736 (0.44)	**	***
TV3RULE	Has TV rule for how many hours child can	0.433 (0.49)	0.438 (0.51)	0.428 (0.49)	0.415 (0.49)	-	**
PHYED	Physical education at school (minutes/week)	47.063 (31.22)	46.962 (31.32)	47.513 (31.41)	47.053 30.65	-	-
ACTYPE	Child involved in at least 2 types of physical	0.523 (0.49)	0.529 (0.49)	0.533 (0.49)	0.514 (0.49)	-	*
raceA	Asian	0.046 (0.21)	0.049 (0.22)	0.039 (0.19)	0.042 (0.21)	***	*
raceB	African American	0.091 (0.29)	0.083 (0.28)	0.095 (0.29)	0.112 (0.32)	*	***
raceH	Hispanic	0.146 (0.35)	0.129 (0.34)	0.162 (0.37)	0.195 (0.39)	***	***
raceR	Other races	0.027 (0.16)	0.025 (0.16)	0.027 (0.16)	0.036 (0.18)	-	***
raceW	White	0.689 (0.45)	0.713 (0.45)	0.676 (0.47)	0.615 (0.48)	***	***
AGE	Child's age	8.082 (1.78)	7.952 (1.76)	8.182 (1.81)	8.505 (1.77)	***	***
GEND	Child's gender	0.495 (0.49)	0.502 (0.50)	0.504 (0.51)	0.456 (0.49)	-	***
BWEIGH	Birthweight	119.167 (20.88)	117.629 (20.64)	121.772 (20.24)	122.841 (21.68)	***	***
NE	Region: Northeast	0.184 (0.38)	0.174 (0.38)	0.198 (0.39)	0.206 (0.41)	***	***
MW	Midwest	0.294 (0.45)	0.299 (0.46)	0.299 (0.46)	0.265 (0.44)	-	***
SO	South	0.314 (0.46)	0.311 (0.46)	0.303 (0.46)	0.334 (0.47)	-	***
URBAN	Urban area	0.352 (0.48)	0.358 (0.48)	0.329 (0.47)	0.349 (0.47)	***	-
TOWN	Large town	0.405 (0.49)	0.411 (0.49)	0.406 (0.49)	0.349 (0.47)	-	***
PRIVATE	Private school	0.229 (0.42)	0.238 (0.42)	0.228 (0.42)	0.195 (0.39)	*	***
PUBLIC	Public school	0.771	0.762 (0.42)	0.772 (0.42)	0.805 (0.39)	*	***
Number of observation		24512	19778	4647	5029		

\*significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%  
Standard deviation in parentheses

## **3.2 Independent variables**

There are four main groups of independent variables: parental time, environmental features, endowment factors which include demographics, and market information. Parental time includes both quantity and quality of time that parents have at home for their children. Environmental variables include factors that contribute to the “nurture” process of raising a child, and endowment variables consist of demographic and the “nature” characteristics of the child. The health demand function includes two other market variables, county-level median housing cost with mortgage and median wage rate.

### **3.2.1 Parental time**

A strong relationship between parental working hours and a child’s BMI has been observed in previous studies (Anderson et al, 2004; You et al, 2005), and between number of hours at work for parents and time spent for both primary and secondary childcare (Baydar et al, 1999, Bianchi et al, 2005). Consistent with the unitary household model assumption in this study, we use total hours of parents’ work-for-pay hours as an explanatory variable<sup>8</sup>. To capture the effect of non-parental care, particularly the source of childcare, we compare non-parental care at the child’s home, at someone else’s home, or at a center, to compare with the base of no non-parental care. Approximately half of the children in the dataset have childcare at kindergarten age, and this percentage decreases to 34 percent at 5<sup>th</sup> grade.

There is a wealth of information from previous research that draws a direct link between dual career families and social outcomes for children such as poor health, behavioral problems, and school achievement. In the context of childhood obesity, the parental time constraints affect households’ food choices, preparation, and consumption patterns, which in turn affect a child’s weight outcome. More than a third of U.S. parents say they eat takeout food regularly and about 20 percent of all meals are consumed in a car (Gardyn, 2002). Single parent households and households with both parents working full time might not have the time to prepare healthy meals, and have a tendency to favor the consumption of prepared foods, which

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<sup>8</sup> We also run regressions with separate working time for the adults, and the results are mentioned and discussed briefly



tend to be high in fat, sodium, and calories, and low in fruits, vegetables, fiber, calcium, and iron (Crockett and Sims, 1995; Videon and Manning, 2003; Mancino and Newman, 2007). Furthermore, working parents also have less time and energy to participate in or supervise children's activities. This means children are more autonomous in choosing their activities which might consist of more sedentary (e.g. computer or video games and TV) and less outdoor activities.

The timing of mothers returning to work after childbirth has been linked to childhood obesity, perhaps due to infant feeding methods (Hammer et al, 1999; Gillman et al, 2001). Approximately three-quarters of mothers return to work between childbirth and kindergarten age of the child. The number of evening meals per week that parents eat with their children is another factor that contributes to a child's weight. It is well documented that children who eat meals with other family members consume more nutritious foods such as fruit, vegetables, calcium-rich foods, and fewer soft drinks (Neumark-Sztainer et al, 2003; Videon and Manning, 2003). Besides, by eating together, parents can be a role model for their children through their eating patterns. This variable has values ranging from zero for "none of the time" to seven for "everyday." The frequency of nine activities that involve both parent(s) and children at home and frequency of times that parent-child share "warm, close feelings" are also used to capture the quality of parental time with their children<sup>9</sup>.

### **3.2.2 Environment**

The importance of family structure and children's well-being has been documented extensively across disciplines such as psychology, sociology, education, and health economics. Single parenthood imposes additional constraints on the household in terms of role models, financial resources, and stability for children. We include dummy variables to indicate whether children live with a single mother, single father, or other arrangements such as stepparents or adoptive/guardian, omitting two-biological parents status. We also

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<sup>9</sup> These activities include read books, tell stories, sing songs, help child do art, play games together, teach child about nature, build things together, do sports together, and child does chores at home.

include a variable to indicate the number of siblings a child has which range from zero to 14. The average numbers vary among ethnic groups.

Family financial resources affect household food patterns directly through food prices and indirectly through the opportunity costs of meal preparation. Research often utilizes an index that indicates the social economic status (SES) of a family as an explanatory variable. The SES is comprised of each parent's career prestige scores, education, and household income<sup>10</sup>. We can use either the composite SES or its separate components in this study. Approximately 17 percent of all households belong to the first (lowest) quintile, 19 percent in each of the 2<sup>nd</sup> and 3<sup>rd</sup>, 21 percent in the 4<sup>th</sup>, and 24 percent in the highest quintile of SES.

Parental education has been associated with health consciousness in terms of nutrition knowledge and food choices (North and Emmett, 2000; Xie et al, 2003). Since the theoretical economic model is based on a unitary assumption, we pool the educational level of parents and use the highest level of the two. A dummy variable is used to indicate if either parent has at least a high school degree.

Thus far there are only a few studies that focus on the relationship between food insecurity and weight problems (Alaimo et al, 2001; Jyoti et al, 2005; Rose and Bodor, 2006). Although there is a compelling argument for this factor in contributing to childhood obesity from a physiological point of view (Drewnowski and Specter, 2004; Drewnowski and Darmon, 2005), the results are mixed, with the effects differing between genders and among ethnic groups. We use a dichotomous variable to indicate whether the household is food secure or not (either with or without hunger). Approximately nine percent of the households in the dataset experience some type of food insecurity during the previous year.

It is hypothesized that households that keep up with routine doctor visits are more likely to maintain good preventive care for their children. The preventive mechanism in the setting of this study might include doctors sharing information and educating parents on health issues, nutritional consumption, and physical

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<sup>10</sup> See appendix for more information on the prestige scores for parents' careers.

activities to keep children at a healthy weight. A dichotomous variable with the value of one indicates parents had their children visit a doctor for routine check-up within a year at the time of the interview.

The literature on childhood obesity shows strong support for the link between children spending more time watching TV and playing computer games and childhood obesity. In fact, one survey shows that American children spend more time watching TV and video and playing video games than doing anything else except sleeping (Robinson, 1999). The effects of these sedentary activities are multifold. They might reduce energy expenditure from displacement of physical activities, and increase dietary energy, either during TV viewing time or as a result of food advertising for children. There are several measures for sedentary activities that are available in this dataset. Categorical variables include whether a household has a computer for the child's use at home, and whether the parents have TV viewing rules such as what programs, how much time per day, and how late the child can watch TV. Continuous variables include the average of the time (in minutes) that a child spends for each activity during weekdays and weekends.

Concurrent to the increase in childhood obesity, many U.S. schools have reduced the commitment to provide students with adequate physical activity/education. A survey in the year 2000 shows that only 8 percent of elementary schools, 6.4 percent of middle schools, and 5.8 percent of senior high schools provide daily physical education for the entire school year for all of the students in each grade (Institute of Medicine, 2005). Physical activity has been shown to effectively prevent or reduce the weight problems in children (Sallis et al, 1997). There are two variables used in this study to capture a child's level of physical activities: 1. an index of the types of activities that a child is involved in, ranging from zero (no activity) to 7; and 2. the time (in minutes) that a child has in physical education at school<sup>11</sup>.

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<sup>11</sup> These are group sports, individual sports, dance, recreational sports, martial art, playground activities, calisthenics/general exercise, or other specified. Due to the potential endogeneity (i.e. reverse causality) of children's physical activities and BMI, we utilize variables that are less likely to be in the child's control or choice set, and require some level of parental instruction or involvement, household rules, or school programs.

### **3.2.3 Endowment**

Race, gender, age, and birth weight are used to control for the endowment, or the “nature”, in explaining childhood obesity. Studies have shown that there is virtually no difference in childhood obesity between genders, but the link between race and obesity is strong. Birth weight is also a strong indicator of developing a weight problem during childhood and adolescent years. Dummy variables are used to indicate female and race (Asian, African American, Hispanic, Others, and White), while actual age (in months) and birth weight (in ounces) are used in this study.

Genetic factors have been cited as an indicator of childhood obesity. However, this hypothesis was partly refuted by the fact that genetic factors do not change in a short period of time, yet childhood obesity rate has been more than tripled in the last 30 years. We use self-reported parental health status as a proxy for this factor. This variable is ranked from zero for excellent health to four for poor health. Approximately 50 percent of parents rank themselves as having excellent health.

It has been documented that the rates of obesity in childhood and adult differ among different regions of the U.S. Generally, southern states such as Alabama, Mississippi, Arkansas, and West Virginia have the highest concentration of obese persons (CDC, 2007). Dummy variables for the four major regions of the U.S., and dummies for central cities, urban fringe and large town, and small towns and rural areas are included. A dichotomous variable indicating whether a school is private is used to compare with public school children.

### **3.2.4 Market information**

County-level median *wage rates* data for all occupations in all industries is used in the health demand function because individual wages are not available. County-level median *housing cost with mortgage* is used to proxy for the cost of living or price levels in an area. According to the year 2000 US Census, about two-thirds (66.2 percent) of all householders own their homes (US Census Bureau, 2001). These two factors are included in the health demand equation as explanatory variables.

## 4. Empirical Results

This section discusses the regression results for the reduced-form health production and health demand equations. Table 2 presents ordered Logit/GLLAMM models with the dependent variable being three categories of BMI: normal, overweight, and obese. Table 3 presents Tobit models with continuous BMI censored at the 85<sup>th</sup> percentile. These results include only variables that are significant at 10 percent or higher.

Table 2: Empirical results for Order Logit/GLLAMM models

Dependent variable: Categorical BMI

Variable	Definition	Ordered Logit/GLLAMM			
		Health Production Function		Health Demand Function	
		Coefficient	SE	Coefficient	SE
TOTHR	Total working hours of parent(s)	1.005***	(0.00)	1.005***	(0.00)
CCHOME	Childcare at child's home	1.119	(0.12)	1.165*	(0.12)
CCOHOME	Childcare at someone else's home	1.337***	(0.13)	1.17**	(0.11)
WOKEARLY	Mother work between childbirth and kindergarten	1.233*	(0.15)	1.109	(0.13)
SingleM	Live with biological mother only	1.296**	(0.17)	1.259**	(0.16)
NUMSIB	Number of siblings child has	0.754***	(0.03)	0.700***	(0.03)
PARED	Parents' education	0.789***	(0.05)	0.819***	(0.05)
IN15C	Household income, <\$15,000/yr	1.586**	(0.31)	1.439**	(0.24)
IN30C	Household income, \$15,001-\$30,000	1.821***	(0.25)	1.692***	(0.21)
IN50C	Household income, \$30,001-\$50,000	1.352***	(0.15)	1.471***	(0.16)
IN75C	Household income, \$50,001-\$75,000	1.246**	(0.12)	1.268**	(0.12)
PAHEALTH	Parents' health	1.328***	(0.06)	1.329***	(0.05)
HOUSECOST	Cost of housing with mortgage, average at county level	--	--	1.000	(0.00)
WAGE	Wages, average at county-level	--	--	1.000	(0.00)
SLUNCH	Child receive complete lunch from school	1.274***	(0.09)	--	--
ACTYPE	Child involved in at least 2 types of physical activities	0.876**	(0.06)	--	--
BWEIGH	Birthweight	1.039***	(0.01)	1.038***	(0.00)
cut_11	Cutpoint between Normal and OW	6.268***	(0.77)	5.768***	0.74
cut_12	Cutpoint between OW and OB	8.933***	(0.77)	8.399***	0.72
ID_cons	Variance at student's level	18.728	(0.74)	18.644	0.72
S2ID_con	Variance at school's level	1.227	(0.16)	1.364	0.15
Number of observation		24504		32613	
Number of student		12719		14601	
Number of school cluster		1811		2377	
Log likelihood		-16574		-21255	
AIC		33243		42592	
BIC		33624		42936	

\*Significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%  
Standard deviation in parentheses  
Logit coefficients are reported as odds ratios

Table 3: Empirical results for Tobit models

Dependent variable: Censored continuous BMI at the 85th percentile

Variable	Definition	Tobit			
		Health Production Function		Health Demand Function	
		Coefficient	SE	Coefficient	SE
TOTHRs	Total working hours of parent(s)	0.003***	(0.00)	0.001**	(0.00)
CCHOME	Childcare at child's home	0.119***	(0.04)	0.046**	(0.02)
CCOHOME	Childcare at someone else's home	0.105***	(0.03)	0.048**	(0.02)
CCOTHER	Other arrangements of childcare	0.258***	(0.09)	0.018	(0.04)
PCHINVOL	Index of parent-child involvement	0.010***	(0.00)	0.002	(0.00)
SingleM	Live with biological mother only	0.115**	(0.04)	0.065**	(0.03)
NUMSIB	Number of siblings child has	-0.123***	(0.01)	-0.091***	(0.01)
PARED	Parents' education	-0.091***	(0.02)	-0.087***	(0.02)
IN15C	Household income, <\$15,000/yr	0.182**	(0.06)	0.101**	(0.04)
IN30C	Household income, \$15,001-\$30,000	0.279***	(0.05)	0.149***	(0.03)
IN50C	Household income, \$30,001-\$50,000	0.174***	(0.03)	0.121***	(0.03)
IN75C	Household income, \$50,001-\$75,000	0.134***	(0.03)	0.088***	(0.02)
PAHEALTH	Parents' health	0.146***	(0.01)	0.057***	(0.01)
HOUSECOST	Cost of housing with mortgage at county level	--	--	-0.030**	(0.01)
WAGE	Weekly average wage at county level	--	--	-0.010	(0.01)
DOC2VIS	Visit doctor for routine care within one year	0.114***	(0.03)	--	--
SLUNCH	Child receive complete lunch from school	0.111***	(0.03)	--	--
BEDTIME	Child goes to bed after 10pm	0.113*	(0.05)	--	--
HOMECEM	Has a home computer	-0.075**	(0.03)	--	--
PHYED	Physical education at school (minutes/week)	-0.001**	(0.00)	--	--
ACTYPE	Child involved in at least 2 types of physical activities	0.054**	(0.02)	--	--
BWEIGH	Birthweight	0.011***	(0.00)	-0.139***	(0.00)
Constant		-8.902***	(0.77)	-0.076**	(0.69)
sigma_u		1.399***	(0.06)	5.019***	(0.02)
sigma_e		4.857***	(0.04)	1.789***	(0.01)
rho		0.077	(0.01)	0.887***	(0.00)
Left censored		16622		21984	
Un-censored		7890		10598	
Number of observation		24512		32621	
Number of student		11188		11909	
Chi-squared		3963.75		5751.76	
AIC		63436.323		69550.05	
BIC		63793.027		69885.72	

\*Significant at 10%; \*\* significant at 5%; \*\*\* significant at 1%

Standard deviation in parentheses

Tobit coefficients are reported as marginal effects

## **4.1. Health Production Function**

Parental total hours of working for pay significantly affect the health status of a child. In the Logit model, an hour increase in total parental work raises the likelihood of a child becoming overweight by .5 percent<sup>12</sup>. Children who are cared for at someone else's house face a greater risk, 34 percent higher, of becoming overweight compared to children who have no non-parental care. Children whose mothers start working early, between childbirth and kindergarten, face a 23 percent higher probability of becoming overweight. Together, these two variables show that non-parental care is detrimental to children's obesity risk, from the early stages of life till elementary school age.

The results from the Tobit model is somewhat stronger, showing that all but center-base childcare arrangement are associated with higher levels of excess weight compared to children with no non-parental care. An hour increase in total parent working time per week leads to a .3 percent increase in children's excess BMI. Likewise, compared to no non-parental care children, those who are cared for by somebody other than their parents at home, at other home, or a combination of childcare arrangements have .12, .11, and .26 units higher in excess BMI scores, respectively.

There are several explanations for the higher risks of childhood obesity from non-parental care methods. Although there are federal funding programs for meals and snacks served to children in licensed childcare entities, only non-profit childcare centers or for-profit with 25 percent or more low income children are qualified. Family childcare homes tend to be small businesses, and their participation is limited (Glanz, 2004). One important characteristic of federal funding programs is that they require these subsidized meals to meet the Dietary Guidelines for Americans, including fat and saturated fat content (Story et al, 2006).

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<sup>12</sup> We also run a parallel model with split time between person 1 (where 85 percent are mothers, 6 percent are fathers, and 9 percent are grandparents or others) and person 2 (i.e. the other adult in the household, when applicable), the results are unchanged, with person 1's hours being statistically significant at 1 percent level and person 2's at 5 percent level.

However, a study by Fox et al (1997) shows that in federal-funded childcare programs, the food component most often missing from meals was fruits and vegetables, and the percentage of calories from saturated fat was higher than the Dietary Guideline level. Previous studies also found that childcare programs vary greatly in their policies and practices that influence children's physical activities (Finn et al, 2002; Pate et al, 2004; Dowda et al, 2004). There are also studies that find children spend more time watching TV in childcare homes than in centers (Fellmeth, 2003).

Higher levels of parental involvement with a child – measured by a frequency index of nine activities – predict a small increase of .01 unit in children's excess BMI scores. There are several hypotheses for this occurrence. First, these activities might have an impact on cognitive skills rather than having a physiological influence. Second, it is common for parents to compensate for a low quantity of time with higher quality of time that they spend with children. Indeed, several sociology studies found that employed-mother households engage in reading/homework activities with their children more frequently than do parents in households where the mother does not work for pay. That is, while employed parents may both spend less time with their children, they need not be sacrificing "quality" time (Bryant and Zick, 1996; Baydar et al, 1999; Zick et al, 2001). Previous economic studies that measure actual time that parents spend with their children also show mixed results. You et al (2005) found that fathers' and mothers' time spent with children are both positively related to children's percentage of energy intake from total fat and saturated fat. Yet father's time is positively and mothers' time is negatively related to children's waist circumference and BMI. The level of parental involvement is statistically significant in explaining how much excess weight a child has given they are overweight, but not the probability of being overweight.

The results above complement another factor: children in single mother households face a higher probability of being overweight – by almost 30 percent – and higher level of excess weight – by .12 unit in BMI scores – compared to children with two biological parents. Perhaps due to the small fraction of



the sample size, the results are not significant for single fathers and adoptive parent/guardian household structures. Previous studies offer several explanations for this trend. Two biological parents might provide a more stable environment, fewer emotional and mental effects that entail any structural changes in the family for their children. Besides, compared to single-parent households, two parents can take roles and support each other in supervising children in understanding nutrition issues, food intake, and physical activities. Therefore, they can help each other to monitor and reinforce different mechanisms to maintain healthy weight or to control the excess weight for their children (Nord and West, 2001; Carlson and Corcoran, 2001).

Other family structure variables, the number of siblings, parents' education and parents' health predict a lower risk of being overweight, and negatively affect excess weight. An additional sibling is associated with a 24 percent lower chance for that child to be overweight. Likewise, parents with at least a high school degree are associated with an 18 percent lower risk of overweight children. Parents who rate themselves as having higher scores (worse health condition) are linked with a 33 percent higher risk of their child being overweight. The same type of results is found with the Tobit model. An additional sibling in a household and an increment in parent education level decrease children's excess BMI scores by .12 and .09 unit, respectively. Children whose parents do not have excellent health ratings score .15 unit higher in excess BMI scores.

Compared to children in households with the highest income level (\$75,000 or higher), children in lower income levels households have higher risk of being overweight, with the \$15,000 to \$30,000 income range having the highest risk and .28 unit higher in excess BMI. This is consistent with previous research where various measures of socio-economic status yield the same result (James et al, 1997; Dietz, 1998; Anderson et al, 2003; McIntosh et al, 2005).

Students who receive a complete lunch from school have 27 percent higher risk of becoming

overweight compared to students who have their food packed from home or eat lunch at home. This factor is also significant for increasing the excess weight in children, by .12 unit in BMI scores. This result is supported by two observations: i) either children do not always choose healthy foods such as fruits and vegetables and prefer calories-dense foods such as French fries when they are available at school (Becker and Burros, 2003), or ii) the food environment at school cafeterias might not provide enough healthy food choices for children (USDA, FNS, 2001).

Several child-related activities such as frequency of doctor visits for routine healthcare, bed time, computer use, and physical education at schools are found to be not significant in predicting weight status, but highly correlated with the amount of excess weight. Children who get routine healthcare check-ups and who go to bed after 10 p.m. have higher levels – .12 unit of BMI – of excess weight. The result of more frequent healthcare visit being associated with a higher excess BMI is a bit puzzling. However, this variable might entail a confounding factor (unobserved) between excess weight and other health problems such as asthma, sleep apnea, and diabetes, which require more frequent check-ups than more healthy children. The relationship between childhood obesity and bed time and sleeping pattern is confirmed by recent research (Agras, 2004; Snell et al, 2007). The mechanism through which sleep loss affects weight is that less sleep leads to tiredness and possibly increased food intake. Physiological factors that results from sleep loss include a low level of leptin, high level of ghrelin and other hormones which affect hunger, food selection, and energy expenditure in general (Taheri, 2006).

Having a computer at home for the child to use is associated with a lower level of excess weight. However, this factor might be correlated with household income and parental education, both of which are negatively associated with overweight as discussed above. A higher level of physical education at school reduces excess BMI. This result confirms previous findings in evaluating effective programs to prevent childhood obesity, although the effect is more pronounced in girls than in boys (Sallis et al, 1997; Gortmaker et al, 1999; Datar and Sturm 2004; Wiecha et al, 2004). Engaging in several types of

physical activity are associated with a lower risk – 12 percent less – of becoming obese and lower levels of excess weight (.06 BMI unit) in children. Together, these two factors imply that intervention policies that affect physical activities should be implemented at both school and home levels.

Control variables such as race, age, gender, urbanization and region of household residence, and a dummy variable for time (each round of data) are all consistent with our hypotheses and previous findings. All races except Asian children have a higher risk of being overweight than Whites, particularly Hispanic and African American children. As a child gets older, the probability of being overweight decreases. Girls in the 5-11 age group face a lower risk of being overweight compared to boys, but both genders are the same in terms of the amount of excess weight. This might be due to the fact that girls are more likely to be sensitive about their appearance compared to boys of the same age (McCreary and Sasse, 2000; O’Dea and Rawstorne, 2001; Kater et al, 2002).

All three regions – Northeast, Midwest, and South – show a significantly higher childhood BMI scores compared to the West region. This is consistent with NHANES data that show lower prevalence of obesity rates in the West region of the U.S. (CDC, 2007). Students from rural areas or small towns have higher BMI scores than urban areas or large towns. The dummies for time variable pick up the idiosyncrasies of each round of data collection.

For the ordered Logit model, the two cut-off points are significant at the one percent level<sup>13</sup>. These are the estimated cut-off points on the latent variable used to differentiate normal from overweight and obese (cut-off 11) and normal and overweight from obese (cut-off 22) when values of the independent variables are evaluated at zero. That is, students who have a value of 5.539 or less on the underlying latent variable that gives rise to the dependent variable BMI would be classified as “normal” given all

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<sup>13</sup> Stata provides only one set of coefficients for each independent variable in Ordered Logit regression. That is, there is an assumption of parallel regression. The majority of the independent variables pass the Brant test for this assumption, except for childcare at child’s home, number of siblings, income between \$50,000 and \$75,000, and gender of a child. See Long and Freese (2001) for more details on this test.

right hand side variables are zero. The estimated variance-covariance with this random intercept model shows that 99 percent of the variation in BMI observed is within student level and only 1 percent is at school level. At the baseline, different schools differ from each other by 1.24 in mean BMI scores while differences among students within a school are greater, with a mean of 18.7 points. The Tobit model passes the quadrature approximation test, which means the results are reliable. Overall, the likelihood ratio test indicates statistical significant at the 1 percent level or better for both models.

## ***4.2. Health Demand Function***

The health demand equations include a vector of prices, wages, and full income but exclude health input factors in explaining the weight status of a child. In both ordered-Logit and Tobit models, all overlapped variables with the health production functions are comparable in terms of signs and most have the same level of statistic significance. Therefore, only several main variables that are different from the health production function above will be discussed here.

The housing cost variable is not significant in predicting children's weight status, but it is negatively correlated with the level of excess weight. Since this housing cost serve as a proxy for cost of living at the county-level, it might also represent other characteristics of the area such as socio-economic and/or particular condensation of an industry (e.g. Silicon Valley in California). Besides, since reduced-form equations are estimated, a variable may intermix several structural effects (Senauer and Gracia, 1991). County-level wage rates are neither significant in predicting children's weight status nor the level of excess weight. Perhaps this factor is highly generalized and thus can not capture the individual effect at the household level. However, as Behrman and Deolalikar point out, the significant effect of the wage rates for women on individual nutrition and health in a cross-section model are not present after correcting for fixed effects (1988). Household's total working hours and income categories stand for the full income in this health demand equation. Both of these variables are positive and significant in predicting children's weight status and explaining levels of excess weight in children.

## **5. Conclusion**

Effective policies and programs to alleviate obesity require an understanding of the underlying determinants. This study adds to the rapidly expanding literature that, in the last several years, has greatly increased our knowledge about factors affecting childhood obesity in the U.S. Given the assumption that both nature and nurture factors affect childhood obesity, this paper seeks to understand the influence of parents' time constraint on childhood obesity in an economic framework of a household production function.

Due to the hierarchical structure of the data, we utilize an ordered Logit in the Generalized Linear Latent And Mixed Models (GLLAMM) that incorporates structural information in estimating the parental time constraint on childhood obesity. We also evaluate these effects on the excess weight once a child is classified as overweight using a random-effects Tobit model.

The results in this study reinforce and extend the findings of previous research in this area. The number of parental working hours (for pay) inversely affects the probability of children being overweight and the amount of excess weight. Children whose mothers return to work early face a relatively higher risk of becoming overweight. Children who receive childcare from private homes are more likely to be overweight and have a higher level of excess BMI compared to children who are cared for by parents, or by center-based childcare services.

Children who live with both biological parents and have siblings are less likely to be overweight compared to other family structures. The effect of these factors might be a result of the underlying household stability. Socioeconomic factors such as parental education, household income, and parental health are negatively correlated with overweight status and the amount of excess weight. These results are in agreement with previous findings across disciplines such as economics, sociology, and epidemiology.

While several children's activities that are controlled for in this study are not significant in differentiating overweight status, they have strong impacts on levels of excess weight. Children who have a late bedtime hours and spend less time in physical education classes at school have higher levels of excess weight. By engaging children in several types of physical activity, the probability of being overweight and the amount of excess weight are reduced substantially. These results imply that there are possible intervention programs that are both home- and school-based to mitigate childhood obesity. Schools can promote good nutrition through healthy school meals and physical activity through physical and health education programs.

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## Appendix

### Coding scheme for selected composite variables in NCES-K dataset

**Social Economic Scale (SES):** computed at household level for the set of parents who completed the parent interview in K grade with these following components

- Father/male guardian's education
- Father/male guardian's occupation
- Mother/female guardian's education
- Mother/female guardian's occupation
- Household income

### General Social Survey (GSS) prestige score for parent's occupation

29.60	Handler, Equipment, Cleaner, Helpers, Labor
33.42	Production Working Occupation
34.95	Service Occupation
35.63	Agriculture, Forestry, Fishing Occupation
35.78	Marketing & Sales Occupation
35.92	Transportation, Material Moving
37.67	Precision Production Occupation
38.18	Administrative Support, including Clerk
39.18	Mechanics & Repairs
39.20	Construction & Extractive Occupation
48.69	Technologist, Except Health
52.54	Writers, Artists, Entertainers, Athletes
53.50	Executive, Admin, Managerial Occupation
57.83	Health Technologists & Technicians
59.00	Social Scientist/ Workers, Lawyers
61.56	Registered Nurses, Pharmacists
62.87	Natural Scientists & Mathematicians
63.43	Teacher, except Postsecondary
64.89	Engineers, Surveyors, & Architects
72.10	Teachers, College, Postsecondary Counselors, Librarians
77.5	Physicians, Dentists, Veterinarians
0	Unemployed, Retired.