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OVERWEIGHT IN ADOLESCENTS: IMPLICATIONS FOR HEALTH EXPENDITURES

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ABSTRACT

We consider two compelling research questions raised by the increased prevalence of overweight among adolescents. First, what factors explain variation in adolescent bodyweight and the likelihood of being overweight? Next, do overweight adolescents incur greater health care expenditures compared to those of normal weight? We address the former question by examining the contribution of individual characteristics, economic factors, parental and family attributes, and neighborhood characteristics to variation in these bodyweight outcomes. For the second question, we estimate a two-part, generalized linear model of health spending. Using data from the Medical Expenditure Panel Survey, our econometric analyses indicate that adolescent bodyweight and the likelihood of being overweight are strongly associated with parental bodyweight, parental education, parental smoking behavior, and neighborhood attributes such as the availability of fresh food markets and convenience/snack food outlets, and neighborhood safety and material deprivation. Our expenditure model indicates that overweight females have annual expenditures that exceed those of normal weight by nearly $800 with part of the disparity explained by differences in mental health expenditures. We use both sets of empirical results to draw implications for policies to address adolescent overweight.

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I. Introduction

The prevalence of overweight among the US population over the past several decades has been characterized as reaching epidemic proportions (Institute of Medicine, 2004). According to data from the National Center for Health Statistics (NCHS), nearly two-thirds of adults were estimated to be overweight during 1999-2002, an increase of 46 percent over rates for the period 1960-62 (National Center for Health Statistics 2004). These data also reveal that 15.8 percent of children aged 6 to 11 and 16.1 percent of adolescents aged 12 to 19 were overweight during 1999-2002, representing nearly a four-fold increase over rates for the 1960-62 period.

Coincident with these trends, overweight among adults and children has emerged as a serious public health concern. Among adults, overweight is a serious risk factor for heart disease, hypertension, Type 2 diabetes, osteoarthritis, poor female reproductive health, and a variety of other physical maladies (Centers for Disease Control and Prevention, 2005). Among children and adolescents, overweight can contribute to a number of physical health problems, including Type 2 diabetes, cardiovascular risk factors, glucose intolerance, sleep apnea, menstrual abnormalities, and orthopedic problems. Perhaps equally important, obesity in children and adolescents can lead to psychosocial problems such as low self-esteem, negative body image, depression, stigma, discrimination, and teasing and bullying (Institute of Medicine 2004; Ogden et al., 2002).

Health problems associated with overweight also translate into substantial health care spending. For example, Finkelstein, Fiebelkorn, and Wang (2003) estimated that overweight and obesity accounted for 9.1 percent of US health expenditures in 1998. Sturm (2002) observed that the association between obesity and chronic health conditions is equivalent to twenty years of aging, and that obesity is associated with significant increases in inpatient and outpatient utilization and prescription drug spending. Wang and Dietz (2002) estimated that for the period 1979 to 1999, obesity-related annual hospital costs for children ages 6-17 increased more than three-fold. Finally, Thorpe et al. (2004) estimated that between 1987 and 2001, the increase in the prevalence of obesity and in spending by the obese relative to persons of normal weight accounted for 27 percent of the rise in real per capita spending over this period.

As described in Koplan, Liverman, and Kraak (2004), overweight is a particular concern for children and adolescents. Apart from the increased likelihood of contracting the adverse health conditions noted above, nearly 50 percent of overweight children and adolescents will become obese adults. Such children are thus at risk for the adverse health conditions and attendant health care costs associated with adult obesity. The social and emotional health problems of overweight children and adolescents can also pose a significant risk to their academic progress, lead to behavioral problems, and impede social adjustment during these critical developmental periods.[1] Finally, should overweight children become overweight adults, they may also obtain lower economic rewards associated with adult overweight and obesity (Gormaker et al. 1993, Averett and Korenman 1996, Cawley 2000, Conley and Glauber 2005).

As Rashad and Grossman (2004) have noted, public policy interventions in response to obesity may be most compelling for children and adolescents who are likely to lack the knowledge necessary for informed nutritional decisions. These informational deficits represent a kind of "market failure" that justifies educational interventions to enhance awareness about

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[1] The Institute of Medicine (2004) also reports that among children and adolescents, rates of overweight are more prevalent in high-risk populations such as children of lower socioeconomic status and racial and ethnic minorities**.** To the extent that children in these groups face barriers to economic success associated with low incomes, single-parent families, low-quality schooling, and residence in inhospitable urban environments, being overweight may exacerbate the difficulties of overcoming such impediments.

nutrition. Excessive myopia may also cause adolescents to undervalue the longer-term consequences of food choices and public policy interventions may again be justified. Additionally, self-control problems may prevent adolescents from taking prudent action in the short-term to address overeating (see O'Donogue and Rabin 2001 for a discussion of risky behavior by adolescents). As with smoking behavior, this lack of self control may warrant government intervention to discourage the consumption of food with poor nutritional content.[2]

Our focus on adolescents also recognizes that this age group is likely to exhibit greater independence in their dietary and nutritional choices than younger children. They may also be subject to less parental supervision regarding sound health habits that can affect bodyweight. Hence interventions designed to alter behavior may have more of an impact on adolescents than on younger children.

In this paper, we first examine the extent to which economic factors, parental characteristics, family structure and composition, and characteristics of neighborhoods and geographic areas contribute to variation in adolescent bodyweight and to the likelihood of being overweight. Next, we consider the relationship between adolescent bodyweight and health care expenditures. This part of the analysis explores whether the relatively high health care costs associated with adult obesity begin to emerge during adolescence. We also examine whether the relationship between adolescent overweight and health expenditures reflects the contribution of weight-related health conditions and whether the prevalence of such conditions differs between overweight adolescents and those of normal weight. Finally, results from our models of adolescent bodyweight are used to point to interventions that can potentially reduce overweight

[2] Gruber (2002/03) provides a non-technical discussion of the use of excise taxes to address problems of self control in the context of cigarette smoking. Papers by Jacobson and Bronwell (2000), Leicester and Windmeijer (2004), and Kim and Kawachi (2006) consider the use of excise taxes to reduce obesity.

in adolescents. As our expenditure models indicate, such reductions could also reduce adolescents' health care spending.

II. Conceptual Framework

As noted above, one of our objectives is to assess the contribution of a variety of factors to adolescent bodyweight and overweight. To frame our cross-sectional analysis, we apply an approach developed by Chou, Grossman, and Saffer (2004, 2002) and note that individual *i's* bodyweight in period *t* will depend on his/her energy balance (the difference between energy consumed, C_i, and expended, S_i), the cumulative effect of his/her energy balance in prior periods (*k=1 to t-1*), and time-invariant factors, represented by the vector V_i, which determine an individual's predisposition to increased bodyweight. We define this relationship as:

$$(1)\ W_{it} = f[(C_{it} - S_{it}), \sum_{k=1}^{t-1}(C_{ik} - S_{ik}), V_i]$$

Rewriting (1) by noting that the terms in the summation and V_i contribute to bodyweight in the prior period (e.g., period *t-1*), we obtain:

$$(2)\ W_{it} = f[(C_{it} - S_{it}), W_{i,t-1}, V_i]$$

Thus, bodyweight observed for individual *i* during the current period will depend on levels of C_i and S_i, bodyweight in the prior period W_{t-1}, and time-invariant, weight-susceptibility factors represented by V_i.

Note that equations (1) and (2) describe the technical or 'production' relationship governing the determination of bodyweight. Since we cannot directly observe this process, our empirical estimates of variation in adolescent bodyweight will be based on reduced-form empirical models. As in Chou, Grossman, and Saffer (2004), we posit that individual characteristics (e.g., age, race/ethnicity, gender, and genetics) will affect the technical process by which *(C-S)* is converted into bodyweight. We also note that current energy balance along with weight in past periods will also depend on economic, family, and neighborhood characteristics.

Apart from technical production considerations, economic theory suggests that individuals ‘choose’ their bodyweight through utility maximizing behavior. As noted by Cawley (2004) and by Chou, Grossman, and Saffer (2004, 2002), bodyweight can enter an individual’s utility function either directly as an object of choice or indirectly as an input in the production of health. Thus, an individual chooses optimal levels of bodyweight and health, along with other commodities, subject to constraints encompassing income, prices of food and other commodities, time, and the bodyweight production function noted above. Since adolescents exercise some discretion in their food choices, we incorporate these considerations in our empirical analysis. Next, we discuss the role of various factors in our model.

Economic factors: Family income and food prices figure prominently as two basic economic factors that can affect adolescent food consumption and bodyweight. First, adolescents in families with higher incomes may be better able to afford foods of superior nutritional quality and lower energy density than lower-income families. Next, adolescents in families with higher incomes may be better able to take part in a greater range of recreational activities than those in low-income families.

Lower prices of fast and convenience foods have been found to be associated with overweight and obesity in adults (Chou, Grossman, and Saffer 2004). In research on children and adolescents, Chou, Rashad, and Grossman (2005) consider the impact of several types of food prices on adolescent bodyweight by gender. While they obtain mixed results, their findings indicate that increases in fast-food restaurant prices reduce adolescent BMI (the body-mass index described below) for females. Finally, Chou, Grossman, and Safer (2004) note that smokers have higher metabolic rates than non-smokers and consume fewer calories. They include the real price of cigarettes in their study to account for the possibility that higher prices may discourage smoking, resulting in increased caloric consumption and higher bodyweight. Chou, Rashad and Grossman's (2005) study of overweight in children and adolescents also accounts for geographic variation in the real price of cigarettes but they find no effect on children's bodyweight.

Parental and family characteristics: Parental obesity may be related to adolescent overweight through a genetic predisposition and/or unobserved parental attitudes toward proper health practices. Early work by Coate (1983) examined the influence of parent's "fatness" (based on skinfold measures) and diet to child and adolescent weight. He found that parent's fatness is a statistically significant predictor of child and adolescent skinfold growth and obesity, but that diet is unrelated to these outcomes. These results support an interpretation in which parental bodyweight affects child overweight through genetics rather than behavior. In more recent work, Anderson, Butcher, and Levine (2003), Sastry and Plebley (2003) and Chou, Rashad, and Grossman (2005) used data on mother's BMI and found it to be strongly related to child overweight. However, if fathers' bodyweight provides a genetic contribution to children's predisposition for overweight, these analyses omit a critical explanatory variable.[3]

Parental and family characteristics may affect adolescent bodyweight through their impact on calories consumed and expended. For example, given the traditional role of mothers in meal preparation, some time-constrained working mothers may substitute less nutritious fast and convenience foods for meals prepared at home. Time-constrained mothers also may exercise less supervision over the food choices of their adolescent children, and higher-income, time-constrained parents have the means to substitute convenience foods for meals prepared at home.

[3] This is an unavoidable problem in analyses of single-mother families since information on the non-residing father will be missing.

Using longitudinal data, Anderson, Butcher, and Levine (2003) found a statistically significant positive relationship between maternal employment intensity and child overweight for children ages three to eleven in high income families. We also include parents' education in our model since it has played a critical role in a variety of other health outcomes for children (Grossman, 2005), and add a variable indicating whether each parent is a smoker, viewing this as a correlate of unobserved parental attitudes toward prudent health behaviors. Finally, family composition and size may affect the ability of parents to adequately supervise the food consumption of their children and to "stretch" budgets to provide high quality meals.[4]

Neighborhood and environmental effects: Differences in the design and environmental characteristics of a neighborhood and the socioeconomic status of its residents may also contribute to the likelihood that an adolescent will be overweight. Such factors include opportunities for walking and recreation, neighborhood safety and quality, and the availability of nutritious food outlets and fast/convenience food stores. Booth, Pinkston, and Poston (2005) cite a variety of studies focusing on the relationship between such characteristics and adult bodyweight. These studies suggest that residents of materially deprived neighborhoods have been found to have higher BMI levels and a greater prevalence of overweight. Other research using individual and state-level data has found that sprawling geographic areas have residents with higher bodyweight and obesity than less sprawling areas (Ewing et al. 2003; Vandgrift and Yoked 2004).

The few studies that have examined the impact of neighborhood characteristics on the bodyweight of children and adolescents have produced mixed results. For example, Kinra et al. (2000) found that children ages 5 to 14 living in materially deprived households in the city of

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[4] Parents' marital status may also affect adolescent bodyweight should emotional and behavioral problems associated with divorce or separation lead to eating disorders.

Plymouth, United Kingdom, had obesity rates 2.5 times the national average. Sastry and Plebley (2003) found that immigrant concentration and neighborhood stability were positively related to the likelihood that an adolescent was overweight. By contrast, Burdette and Whitaker (2004) found no relationship between neighborhood characteristics such as safety, the availability of playgrounds, and fast food restaurants on overweight among low-income, pre-school children. Kandris and Liu (2003) found that when median income was included in multivariate models, social barriers such as crime and single parenting were not statistically significant predictors of obesity for children (ages 4 to 18 years of age) living in areas of low income in Indianapolis. They also found that opportunities for exercise were not statistically predictive of obesity nor was census tract educational attainment.

Finally, in evaluating the impact of such community-level characteristics on outcomes for children, Ginter, Haveman, and Wolfe (2000) have cautioned that the reliability of estimates of neighborhood effects depend on the degree to which family background is included in model specifications. Sastry and Plebley (2003) also found that inclusion of family characteristics reduced the contribution of the small number of neighborhood characteristics in their analysis of children's bodyweight and obesity.

The relationship between adolescent bodyweight and health care expenditures:

As noted earlier, we examine whether overweight adolescents incur higher health care expenditures than adolescents of normal weight in order to gain insight into whether the high health expenditures of overweight adults have their origin during adolescence. While there is a relatively large literature on variation in child and adolescent bodyweight, and a descriptive literature regarding the contribution of adult obesity to aggregate health expenditures, we are not aware of behavioral analyses on adolescent overweight and health care spending. Our analysis seeks to address this gap in research by estimating an empirical model of health expenditures. As discussed below, this model specification confronts several issues of endogeneity as well as the critical question of whether any expenditure differentials by bodyweight can be attributed to health conditions that are associated with overweight in adolescence.

III. Data and Empirical Specification

The data used in this study are from the household component of the Medical Expenditure Panel Survey (MEPS-HC), a nationally representative two-year household panel survey sponsored by the Agency for Healthcare Research and Quality (AHRQ). The MEPS provides national estimates of the civilian, non-institutionalized population's access to, use of, and expenditures for health care, their health and health insurance status, demographic characteristics, economic status, and employment characteristics. It also includes data on reported (rather than measured) height and weight of adults and children. For children, these data are reported by parents (or other responsible individuals) while for adults, self-reported data on height and weight were collected beginning in 2001. For public release, these data are converted into units of BMI for each adult and child, defined as weight in kilograms divided by height in meters squared.

For purposes of our analysis, we pool MEPS household survey data for the years 2001 through 2003, the latter year representing the most currently available data at the initiation of our study.[5] We excluded female adolescents who were pregnant, restricted our analysis to

[5] Specifically, we begin with data from the second year of panel 5 (corresponding to 2001), representing the first year in which data on adult height and weight were collected in the MEPS. We also include data from the first year of panel 6 (corresponding to 2001), the first year of panel 7 (2002), and the first year of panel 8 (2003). We considered exploiting the panel nature of MEPS to examine changes in adolescent bodyweight between year one and year two of the

adolescents residing with single-mother and two-parent families, and excluded those with missing or implausible values of BMI. Our resulting data set consists of 6738 adolescents (3463 males and 3275 females) defined as ages 12 to 19 to be consistent with classification of adolescents in National Health and Nutrition Examination Survey (NHANES) from NCHS. We apply survey weights to our analyses so that our estimates represent annual average estimates for the three years of pooled data in our sample. We also adjust the standard errors of our descriptive and multivariate estimates for the complex survey design of MEPS using the relevant survey commands in STATA.

Data on adolescent and adult BMI and overweight: Data on BMI used to classify children as overweight are based upon U.S. age-and gender-specific growth charts (BMI-for-age percentiles) tabulated by NCHS. We use these BMI threshold levels to classify adolescents into four weight categories: underweight (< 5th percentile); normal weight (5th percentile to < 85th percentile); at risk of overweight or obesity (85th percentile to < 95th percentile) and overweight (95th percentile or above).[6] For parents, we use the NCHS classification of underweight as BMI < 18.5; normal weight (BMI > or equal to 18.5 but < or equal to 24.9); at risk for obesity (BMI > or equal to 25 but < or equal to 29.9); and obese (BMI > or equal to 30).[7]

MEPS panels. However, we found that changes in the BMI index for adolescent children were quite small over this two year period.

[6] We follow the Centers for Disease Control and Prevention and use ‘overweight’ to refer to children who are in the top 5 percent of their gender and age-specific BMI distribution.

[7] Missing data on BMI, due to non-response to questions on weight and/or height, ranged from just over 15 percent for children 12 years of age to less than ten percent for those 15 to 19. We found that children 17 – 19 years of age sometimes had a value for the variable measuring adult BMI. For consistency in measuring adolescent BMI and for purposes of minimizing the degree of missing data, we adopted the following decision rule for these observations: if values existed for both the child BMI and adult BMI measures, we used the child BMI; if the child BMI was present and the adult BMI missing, we used the child BMI; if the adult BMI was available and the child BMI missing, we used the adult BMI.

As noted, MEPS BMI data for children and adolescents are based upon parental reports of height and weight rather than measured values. Consequently, there may be measurement error due to possible over-reporting of height and under-reporting of weight that could bias estimates of BMI downward. To assess this possibility, we compared our BMI estimates to tabulations based on measured BMI from the NHANES for the period 1999 to 2002 (Table 1). Overall, we find a somewhat lower proportion of overweight adolescents in our sample, 14.2 percent, compared to 16.1 percent from the NHANES ($p < 0.05$). We find no statistically significant differences between overweight rates for male adolescents (15.8 percent in the MEPS and 16.7 percent in the NHANES), but do find a lower percentage for female adolescents in the MEPS (12.5 percent to 15.4 percent in the NHANES ($p < 0.05$).

We also examine adolescent overweight rates by race/ethnicity and gender to try to identify the source of under-reporting. Although there is a 2.8 percentage point difference in overweight rates between white females in the MEPS and NHANES, this difference is not statistically significant. While we find no statistically significant differences between MEPS and NHANES with regard to black males, black females, white males, and black females, published NHANES tabulations do not provide estimates for adolescents of Hispanic ethnicity (estimates are only provided for Mexicans). Thus, the difference between the overall MEPS and NHANES estimates could potentially reflect differences in the prevalence of overweight for Hispanic females.[8]

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[8] Cawley and Burkhauser (2006) use the NHANES to regress data on measured weight (height) on reported weight (height) and use the resulting equations to predict height and weight (and thus BMI) corrected for reporting error. Unfortunately, the NHANES does not contain both reported and measured data on weight and height for children less than age 18 so we are unable to apply such an adjustment procedure. Goodman, Hinden and Khandelwal (2000) find that self reports of height and weight by adolescents provide accurate estimates of BMI for classifying adolescents

Data on economic factors: Income data reported in the MEPS, expressed as a percent of the federal poverty line, serves as our measure of household economic status. We use data from the 2002 Economic Census: Accommodation and Food Services, Geographic Area Series to obtain information on the average state price for limited-service restaurants and full-service restaurants in the adolescent's state of residence.[9] These data are produced every five years so that the 2002 data are most appropriate for our study. Since the price data are reported as specific intervals, we apply weights to price interval mid-points where the weights are the percent of each type of restaurant in each interval (as in Chou, Grossman, and Saffer 2004). We attempted to use the ACCRA Grocery Items Price Index for selected metropolitan statistical areas to measure the price of food prepared at home (ACCRA 2005). However, since data for this index was missing for half our sample, we decided not add it to our analysis. Finally, we also include measures of the average price per pack of cigarettes in a state (2003 dollars) as reported in *The Tax Burden on Tobacco* (Orzechowski and Walker 2006).

Parental characteristics and family circumstances: We classify each parent as employed or not employed, and for mothers we classify them, if employed, as working full or part time (where full-time work is defined as 35 or more hours per week). Other family and parental characteristics, such as family size, parents' bodyweight, education, health and smoking status are also obtained from the MEPS.

Data on geographic locale and neighborhoods: We incorporate several measures of an adolescent's geographic location that may have relevance for bodyweight and the likelihood of

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as overweight. However, we are not aware of studies that compare parental reports of children's height and weight to measured data for purposes of identifying overweight adolescents.

[9] These data were accessed via the American Fact Finder web site at http://factfinder.census.gov/servlet/IBQTable?_bm=y&-geo_id=&-ds_name=EC0272SXSB02&-_lang=en last accessed on May 10, 2006.

being overweight. We include data on census tract population density derived from the 2000 Census and expect that individuals residing in more densely populated tracts may have less incentive to use motorized transportation for daily activities. We also use census tract data on the percent of households on public assistance, the percent of vacant households, and the median value of housing to characterize neighborhood material deprivation. We expect such neighborhoods to lack adequate recreational facilities, have poorer environmental quality, and lack access to higher quality and more nutritious food products than more affluent neighborhoods.[10]

Our analysis also includes variables characterizing county crime rates as an indicator of neighborhood safety and hence, the ability to engage in outdoor and recreational activities without feeling threatened. We obtained county-specific crime data from the US Department of Justice Uniform Crime Reporting Program Data for the year 2002. In our analysis, we focus on crimes against individuals (murders and aggravated assaults) rather than crimes against property.

Finally, we also include county-based measures of types of food outlets per capita. These include convenience and snack food stores (the latter include confectionary and nut shops, ice cream, soft serve, and frozen yogurt stores, and doughnut, bagel, and cookie shops), fish and seafood markets, fresh vegetable markets, supermarkets, and full-service restaurants and limited-service restaurants. Since convenience stores, snack food outlets, and restaurants are generally considered to serve high caloric and energy-dense foods compared to food prepared at home, we expect that a greater presence of such food outlets will be associated with increased adolescent BMI and the likelihood of being overweight. In contrast, we expect the greater availability of fish and vegetable markets to be associated with the reduced likelihood of overweight and a

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[10] Our exploratory analyses included additional neighborhood characteristics. Since these variables did not attain statistical significance, our final model includes the above subset.

lower BMI. These data are also obtained from the 2002 Economic Census: Accommodation and Food Services, Geographic Area Series compiled by the Bureau of the Census.

Data for health care expenditure modeling: We estimate models of adolescent medical expenditures (in 2003 dollars) and include indicators of an adolescent's health insurance status, specifically whether an individual is insured by either private or public insurance for all or part of the year (adolescents uninsured all year represent the reference group). Our expenditure models, estimated separately by gender, also include information on the characteristics of adolescents (e.g., their age, race/ethnicity, region of residence), family characteristics (including family size, family income as a percent of the federal poverty line, and whether the adolescent resides in a single or two-parent family).

We also include parental characteristics that may affect an adolescent's use of medical care and health status. These include parents' educational attainment, whether parents smoke, and the employment status of each parent. Parents with higher educational attainment are more likely to have children in better health than those with lower education (Grossman 2005). However, while better educated parents may be more efficient and knowledgeable producers of child health, the implications for health expenditures are not clear and depend upon their relative use of parental time and medical care resources in producing child health compared to parents with lower educational attainment. Adolescents residing with parents who smoke may be subject to illnesses associated with second-hand smoking and thus require more medical care than those residing with non-smoking parents. Additionally, parental smoking may also reflect attitudes regarding health and preventive behaviors that can also affect the demand for medical care. Parental employment (especially full-time employment) may impose greater time costs on parents and thus constrain the number of medical care visits during the year compared to parents working part-time or who are not employed.

Finally, we also include the Center for Medicare and Medicaid Services' hospital wage index to control for cross-sectional variation in medical care costs. The wage index expresses the hospital wage level in the geographic area of the hospital compared to the national average hospital wage level for hospital labor market areas.[11]

Empirical specification: We estimate an OLS model for adolescents' BMI and probit models for the likelihood of being overweight and also for the combined category of the likelihood of being at risk for overweight or overweight. [12] To model medical expenditures, we estimate a probit model for the probability of any expenditure and a GLM model for persons with positive expenditures. The GLM model is characterized by a logarithmic link function and by a variance function that is proportional to the mean squared (represented as a gamma distribution). Expected expenditures are predicted for all adolescents in our sample (spenders and non-spenders) by combining predictions from the probit and GLM models.

In selecting the two-part GLM model, we examined alternative functional forms including a standard two-part model (probit in the first stage and log-linear conditional expenditure function) and a one-part GLM model. We focused on comparisons of the two part models since we view the decision to obtain any medical care and the decision regarding the level of care obtained (as summarized by expenditures) as qualitatively different processes warranting separate estimation. We selected the two-part GLM model for the following reasons.

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[11] See http://www.cms.hhs.gov/AcuteInpatientPPS/03_wageindex.asp for a full description (last accessed on 4 April 2007).

[12] We also considered modeling adolescent bodyweight as an ordered logit model with categories based the weight classes defined above. However, only the cutoff point for overweight was was consistently statistically significant in preliminary analyses so that we focused on the dichotomous outcome "overweight or not overweight."

First, our estimates of the conditional log-linear model in the standard two-part model displayed evidence of heteroskedasticity. As Manning and Mullahy (2001) have noted, such heteroskedasticity can yield biased estimates unless separate smearing estimators are applied, a process that can be quite cumbersome when residuals are correlated with several explanatory variables. By contrast, estimates of the conditional GLM model were consistent with evidence of normally distributed residuals (kurtosis estimates of 2.98) and with a gamma variance function (Park's test statistic was approximately 2). Next, when we examined predicted expenditures by adolescent bodyweight class, mean estimates from the standard two-part model were far below actual mean values. The two-part GLM model yielded mean expenditure estimates that compared favorably to observed mean expenditures in each adolescent bodyweight class. Finally, we applied a variant of the Hosmer-Lemeshow test to examine the goodness-of-fit of our GLM model across our bodyweight classes. We ran a regression of the residuals from the GLM model on our four bodyweight classes (run without a constant). The results indicated that the coefficients on the bodyweight class variables were not statistically significant, suggesting that our functional form fit the data well.

Omitted health conditions and endogeneity issues: As specified, our model of adolescent health expenditures excludes specific health conditions that are associated with adolescent overweight. The presence of such conditions may lead to higher expenditures for overweight adolescents compared to adolescents of normal weight. As a result, one could argue that our model ignores an important source of endogeneity: the correlation between our bodyweight variables and these omitted health condition variables. However, we have purposely excluded such conditions since we are interested in the *overall* association between adolescent overweight and health care expenditures. Put differently, we want the coefficients on our overweight variables to capture the correlation between being overweight and having these related health conditions. In this way, we can fully attribute the expenditures associated with such conditions to being an overweight adolescent. In our empirical work, we examine whether the prevalence of health conditions attributable to being overweight is in fact greater for our sample of overweight adolescents compared to those of normal weight. We also examine whether the inclusion of such conditions directly in our model can explain any differential in predicted expenditures between overweight adolescents and those of normal weight, and thus, whether expenditure differentials do indeed reflect the contribution of weight-related health conditions.

Next, there may be other sources of endogeneity that confound our expenditure estimation. As noted above, MEPS data on adolescent BMI are obtained from parental reports of height and weight rather than from direct measurement so that the computed BMI may be reported with error. As noted above, should such unobserved measurement error be correlated with the observed measure of BMI, we will obtain inconsistent estimates of coefficients on our explanatory variables. Additionally, there may also be reverse causality or structural endogeneity between health expenditures and being overweight. For example, high health expenditures resulting from unobserved health conditions that limit physical activity or from unobserved medical treatments (e.g., drug therapy) may result in increased bodyweight for some adolescents. While these sources of endogeneity in measured BMI could be addressed through an instrumental variables (IV) approach, we are constrained in applying such an approach. Use of IV will also purge our overweight measure of the unobserved health conditions that are correlated with being overweight and whose expenditures we wish to attribute to being overweight.

IV. Findings

Results from the empirical models of adolescent bodyweight are reported in Tables 2 and 3 for males and females, respectively. Each table presents results for our three models: our OLS model of continuous BMI (column 1); our probit model for adolescents who are at risk of becoming overweight or who are overweight compared to those who are of normal weight or are underweight (column 2); and our probit model for adolescents who are overweight versus being in the other weight classes (column 3). We focus on these alternative outcome measures to provide a comprehensive evaluation of the impact of family, economic, and neighborhood factors on adolescent bodyweight.

Male adolescents:

The most striking finding in our models of adolescent bodyweight is the strong relationship between parent's bodyweight class and adolescent weight outcomes. In particular, male adolescents whose parents are obese or at risk for obesity (compared to those whose parents are of normal weight) have increased BMI scores and are more likely to be overweight or at risk for overweight. For example, having a mother (father) who is obese increases the likelihood that a male will be overweight by 13.7 (7.4) percentage points.[13] As noted, this relationship is likely to reflect an adolescent's genetic predisposition to increased bodyweight and/or parental attitudes toward nutrition, exercise, and healthy lifestyles.

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[13] Marginal effects were obtained for discrete variables by first assuming each observation to have the characteristic of interest, predicting the probability of the adolescent being overweight or at risk for overweight and then averaging. The same procedure was used assuming each observation did not have the characteristic of interest. The difference between predicted mean probabilities with and without the characteristic of interest represents the marginal effect associated with that characteristic. For continuous variables, the marginal effect was calculated for a change of one standard deviation in the variable. Standard errors were obtained for the marginal effects using the balanced repeated replication method.

Somewhat surprisingly for male adolescents, we find that father's education rather than mother's education has a more consistent impact on our outcome measures. Males whose fathers have at least a high school education have lower BMI scores and lower probabilities of becoming overweight or at risk of overweight. We find that males whose mothers attended but did not graduate from college have lower BMI levels and lower likelihoods of being overweight ($p < 0.10$ in both models). While the difference in statistical significance for each parent's education may reflect the correlation between the mother's and father's education levels, it may also reflect a greater influence of fathers on male adolescent behavior.[14] Finally, we find that parental smoking status is positively associated with adolescent bodyweight. Males whose mothers smoke have higher BMI scores and are 3.6 percentage points ($p < 0.10$) more likely to be overweight and 5.5 percentage points more likely to be at risk for overweight or overweight.

Mother's employment status attains statistical significance in the male BMI and overweight/at risk regressions although in ways contrary to our expectations. While we expected work activity, especially full-time employment, to result in increased adolescent bodyweight, we find just the opposite effect: male adolescents with part-time working mothers exhibit lower BMI scores than those without employed mothers, and males having a full- or part-time working mother are less likely to be at risk/overweight (column 2) than those with stay-at-home mothers (the former result is significant at $p < 0.10$). This finding contrasts with results in Anderson et al. 2003 who found a positive relationship between maternal employment and children's weight. Our results may differ from their study due to our use of cross-sectional rather than longitudinal data. Below, we examine some sensitivity tests regarding the relationship between mothers'

[14] Excluding the father's education increased the statistical significance on some of the mother's education coefficients but they were not as consistently statistically significant as those for the father.

employment and male bodyweight. Finally, given the large proportion of fathers who are employed in our data (91 percent among two parent families), we find no impact of fathers' employment status on any of our bodyweight outcome measures.

We do find evidence that male adolescents in households with incomes in excess of four times the poverty level are more likely to be overweight/ at risk for overweight than other adolescents. Since there is no income effect in the overweight equation, this likely reflects the impact on the risk of being overweight. We find that increased family size is associated with reductions in bodyweight for each of the outcome measures. This finding may reflect the inability of some income-constrained households to provide adequate meals for their family members or to limit discretionary spending on snack foods. Finally, we find some differences in adolescent bodyweight according to race and ethnicity. Male adolescents who are Hispanic have higher bodyweight outcomes for all measures than white males and are 6.5 percentage points more likely to be overweight (10.8 percentage points more likely to be either at risk for or overweight).

We find very little evidence that neighborhood and geographic factors have an impact on male adolescent bodyweight with two noteworthy exceptions. First, we find that higher state cigarette prices result in increased male BMI (column 1, $p < 0.10$), consistent with the notion that higher cigarette prices may induce a substitution of food consumption for smoking. However, since we find the opposite effect for females (discussed below), these results need to be interpreted with caution. We also find that male adolescents in counties with greater snack/convenience food stores per capita are more likely to be overweight, while those in counties with more fresh food stores per capita are less likely to be overweight. A change of one standard deviation in these variables from their means yields small changes in the likelihood of being overweight: a 2.1 percentage point increase and a 1.7 percentage point decrease in the likelihood of being overweight, respectively. Finally, we also find that male adolescents in neighborhoods with higher percentage of persons on public assistance are more likely to be overweight ($p < 0.10$). Such a finding may reflect a correlation between neighborhood economic status and unobserved indicators of neighborhood amenities (e.g., recreational facilities) that are conducive to physical activity and reduced bodyweight.

Female adolescents: Female bodyweight outcomes also display the very strong relationship with parents' bodyweight that was observed in the male equations, with nearly identical effects (Table 3). For example, female adolescents whose mothers (fathers) are obese experience a 13.1 (7.2) percentage point increase in the likelihood that they will be overweight. While we find no impact of parents' educational attainment, employment, or family income on weight outcomes for females, we do find that parents' smoking behavior has some impact. In particular, female adolescents whose fathers smoke have higher BMI scores, are 4.0 percentage points more likely to be overweight, and are 7.1 percentage points more likely to be at risk for overweight or overweight than those whose fathers are non-smokers. Finally, we find that females with mothers in fair or poor health are more likely to be overweight than those whose mothers are in good or excellent health ($p < 0.10$). Mothers in poor health may be less able to take an active role in meal planning and preparation resulting in greater use of high caloric prepared foods.

We find a different pattern of racial/ethnic disparities in bodyweight for females than for males. Female adolescents who are Hispanic or black exhibit higher BMI scores compared to white females. In addition, black adolescent females are 4.7 percentage points more likely to be overweight and 5.5 percentage points more likely to be at risk for overweight or overweight ($p < 0.10$ for both) than those who are white.

Female adolescent bodyweight displays some association with neighborhood and geographic characteristics. We find evidence that increases in population density are associated with lower BMI scores ($p < 0.10$), a finding that may reflect the ability to do without motorized transportation in more densely populated areas. Contrary to expectations, we find a non-linear, positive relationship between a state's average limited-service restaurant price and the likelihood of being overweight. Since this variable is not standardized for serving size, the positive relationship may reflect the impact of larger serving portions on bodyweight. We also find that an increase in the number of full-service restaurants is associated with a decline in all bodyweight outcome measures but we do not have an obvious explanation for this finding. Finally, we find that an increase in the number of county snack and convenience food outlets per capita is associated with an increased likelihood that an adolescent female will be at risk for overweight or overweight (a 2.7 percentage point change for a change of one standard deviation in this variable); we find no evidence of this effect when considering the likelihood of being overweight.

In contrast to findings for male adolescents, increases in the real price of cigarettes are negatively related to the likelihood of being an overweight female, a result that is at variance with expectations. We also find some evidence that neighborhood safety and quality may be related to overweight in adolescent females. Adolescent females residing in counties in the top two quartiles of the distribution of murders per capita are more likely to be overweight than those residing in neighborhoods in the bottom quartile (a 3.6 and 4.9 percentage point increase, respectively; the former at $p < 0.10$). Additionally, females residing in neighborhoods in the second and fourth quartiles of murders were more likely than those in the bottom quartile to be in the combined category of at risk for overweight or overweight (5.3 and 7.4 percentage points, respectively). We also find that females in neighborhoods with an increased proportion of vacant housing units are somewhat more likely to be overweight (a change of 1.3 percentage points for a one standard deviation change in this variable, $p < 0.10$). Consequently, concern over personal safety and possible lack of neighborhood amenities (as reflected in increased vacancy rates) may discourage physical activity and contribute to overweight in adolescent females.

Sensitivity Tests:

Parent's employment: Since our results with respect to maternal employment differ from those in prior work, we re-examined this relationship by restricting our sample to adolescents with working mothers as in the longitudinal analysis of Anderson et al. (2003). By doing so, we observe a positive relationship between mother's hours of work and the likelihood of being overweight but only for males ($p < 0.10$ for a two-tailed test). Since Anderson et al. found the impact of mother's hours to be greatest in high-income families, we examined regressions for our restricted sample further broken down by family income in relationship to the poverty line. We found no evidence of a positive relationship between mothers' hours of work and weight outcomes for either gender.

Adolescent age group: Since our sample of adolescents between ages 12 and 19 may differ in their degree of independence regarding food choices and physical activity, we examined bodyweight regressions for the following age groups: 12 to 14, 15 to 17, and 18 and 19. These regressions yielded little in the way of new information regarding differences in the correlates of bodyweight. One interesting finding to emerge for females is that for the oldest and presumably most independent age group, mother's hours of work were positively correlated with an increased likelihood of being at risk for overweight or overweight. However, no effect was found on the likelihood of being overweight by itself.

Adolescent bodyweight and health expenditures:

Male adolescents: In Table 4, we report results of our expenditure models for male and female adolescents. We find no evidence that males who are overweight, at risk of being overweight, or underweight have a greater likelihood of incurring an expenditure (probit model in column 1) or higher conditional expenditures (GLM model in column 2) compared to males of normal bodyweight. Consistent with these findings, predicted expenditures for each bodyweight class based on the two-part GLM model reveal no statistically significant differences across bodyweight classes.

The regression models for males yield a number of plausible results. For example, males with full-year or part-year insurance coverage have a greater likelihood of incurring expenditures and have higher conditional expenditures than those uninsured all year. We also find that older males, blacks and Hispanics (compared to whites), and those in larger families are less likely to incur an expense. For both the probit and GLM models, we find that mother's rather than father's education is associated with a greater likelihood and level of health care spending. Other findings from the GLM model indicate that males in high-income households incur greater expenditures than those who are poor or near poor, and males with time-constrained mothers (those working full time) have lower expenditures than those whose mothers are not working (both at $p < 0.10$).

Female adolescents: In contrast to males, we obtain striking expenditure differences for female adolescents across bodyweight classes (Table 4). We find that overweight females have both a higher likelihood of incurring expenditures and higher conditional expenditures than those of normal weight. While females at risk of being overweight are no more likely to incur expenditures than females of normal weight, they do incur higher conditional expenditures.

Finally, underweight females are less likely than those of normal weight to incur health expenditures but their conditional expenditures are no different than females of normal weight.

As with males, adolescent females insured all or part year are more likely to incur expenditures and but their conditional expenditures are no different than those uninsured all year. Hispanic, black, and Asian females are less likely to incur expenditures than whites, with Asians ($p < 0.10$) and those of other racial or ethnic groups having lower conditional expenditures than whites. We find that females incur higher conditional health expenditures if their mothers had more than a high school education and if their fathers graduated from high school compared to those not graduating from high school. Finally, females in middle and high income families (with incomes three or more times the poverty line) have higher conditional health expenditures than those who are poor or near poor (less than 125 percent of poverty), and those with full-time working mothers incur lower conditional expenditures than females with stay-at-home mothers.

Predicted health expenditures by female bodyweight:

Our empirical work reveals that overweight females are more likely than those of normal weight to incur health expenditures and when they do, to have higher expenditures. The findings also indicate that when female adolescents at risk of being overweight incur health expenditures, their spending also exceeds that for females of normal weight. Combining results from each part of the model, we obtain predicted expenditures according to female bodyweight. In doing so, we derive estimates for each bodyweight class that are based on our full sample of adolescent females. Using this standard population allows us to obtain expenditure estimates for each bodyweight class that are not confounded by differences in characteristics by bodyweight.

We find that overweight female adolescents have average annual health expenditures of $2101 compared to $1311 for those of normal weight, a statistically significant difference of

$790 in annual expenditures ($p < 0.05$). Additionally, female adolescents at risk of becoming overweight have predicted expenditures of $1778, $467 above expenditures for those of normal weight ($p < 0.10$). We find no difference between expected expenditures for underweight and normal weight females ($1565 and $1311, respectively), nor do we find differences between overweight and at risk females. Thus for adolescent females, being overweight yields a substantial increase in annual health spending compared to spending by females of normal bodyweight.

Adolescent female health expenditures, bodyweight, and health conditions:

In order to determine whether the expenditure differences by bodyweight class are attributable to weight-related health conditions we applied several empirical tests. First, we considered whether there were differences in the prevalence of such conditions between females who were overweight or at risk of overweight and those of normal bodyweight. These conditions included diabetes, hypertension, heart disease, cerebrovascular disease, other circulatory diseases, mental disorders, and a composite variable consisting of other health conditions associated with childhood overweight.[15] We found that the prevalence of mental disorders for overweight females exceeds that for females of normal weight (16.5 percent of the former compared to 10.9 percent of the latter), as did the prevalence of diabetes (1.9 percent compared to 0.3 percent), and hypertension (2.3 percent compared to 0.06 percent), all differences statistically significant at $p < 0.05$. Additionally, overweight females had a higher mean value of the Columbia Impairment Scale (CIS) than females of normal weight (18.2 to 8.8), where the CIS measures global impairment derived from 13 questionnaire items defined to assess

[15] The conditions noted, along with the composite variable, represent a subset of the health consequences of overweight in children and youth. For a full listing, see the Institute of Medicine Fact Sheet (2004).

interpersonal relationships, psychopathologies, job or school work, and use of leisure time. When we compared female adolescents at risk for overweight to those of normal weight, the only difference found was in mean CIS (14.3 to 8.8 respectively, $p < 0.05$).

Next, we included these conditions in our conditional expenditure model for females to examine their effect on the coefficients of our weight class variables and whether they exhibited an independent effect on expenditures.[16] While the coefficients on such conditions (except other circulatory conditions) were positive, only the coefficients on mental disorders and heart disease were statistically significant.[17] The coefficients on the overweight and at risk for overweight variables remained statistically significant ($p < 0.10$ for the latter). However, while their magnitudes were reduced they were not significantly different from their coefficients in our initial specification.

As reported in Table 5, the addition of these weight-related conditions and the consequential change in coefficients reduced predicted expenditure differentials. The differential between overweight females and those of normal weight declined from \$790 to \$660, and the differential between females at risk of overweight and those of normal weight declined from \$467 to \$252. However, estimates of these differentials are not precisely measured and must be treated as suggestive: when compared to the expenditure differential without conditions, the comparisons fail to attain statistical significance.

Since nearly a fifth of overweight female adolescents and 12 percent of those at risk for overweight have mental health conditions, we partitioned total expenditures into two components

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[16] Since the condition variables are primarily collected when medical care encounters are reported, they are closely correlated with the likelihood of incurring expenditures. Thus, we restricted the use of the condition data to our conditional expenditure model.

[17] The imprecise results for other conditions may reflect their relatively low prevalence in our sample of adolescents.

– (1) expenditures net of mental health spending (excluding inpatient and outpatient services and prescription drugs) and (2) mental health expenditures – and estimated our model on these two outcome variables. In the former model, the expenditure differential between overweight and normal-weight females was $622, and the differential between females at risk for overweight and those of normal weight was only $68 (Table 5). However, the reduced expenditure differentials are not significantly different from their initial values. In our mental health expenditure model, we found that compared to females of normal weight, overweight females incurred an additional $208 in annual mental health expenditures while those at risk for overweight incurred an additional $286. Thus, this more direct test is consistent with the hypothesis that differences in the use of mental health services by bodyweight class may partly explain the disparity in health expenditures between adolescent females of normal weight and those who are either overweight or at risk of being overweight.

In sum, these analyses suggest that at least some of the disparities in annual health expenditures between female adolescents of normal weight and those who are either overweight or at risk for overweight are related to health conditions associated with excess bodyweight. While our findings do not explain all of the expenditure differences, this may reflect the fact that for many weight-related conditions, we lack adequate sample size and hence statistical power to obtain precise estimates of the reduction in expenditure differentials. Additionally, we lack data on the intensity of care received for each of the weight-related health conditions that will also contribute to differences in health expenditures. Nevertheless, the analysis suggests that mental health problems may contribute to these expenditure differentials and points to the need for more research on the relationship between adolescent overweight and mental health problems.

V. Conclusions and Implications

The increase in the prevalence of adolescents who are overweight during the past four decades has raised two compelling research questions. First, do an adolescent's individual characteristics, family circumstances, and economic and geographic environment help to explain differences in the likelihood of being overweight? Second, is overweight in adolescents associated with health care problems that yield higher health expenditures than incurred by adolescents of normal weight? The latter question is particularly important since nearly half of all overweight adolescents and children will become obese adults and potentially susceptible to the health conditions and high health expenditures associated with adult overweight. Our research explores whether these high health expenditures have their origins among teenagers who are overweight. Focusing on both questions also recognizes that public policy interventions to address overweight may be especially compelling for adolescents. They are more likely than younger children to make independent food choices, may (along with their parents) lack information on the nutritional implications of such choices, and may fail to recognize the long-term health consequences of poor nutrition.

In addressing the first question, we employed a rich set of data on individual and family-level characteristics from the 2001-2003 MEPS along with secondary data describing the availability and price of food purchased outside the home, and the economic status, quality, and safety of neighborhoods. Our findings in this regard point to the strong relationship between parental and adolescent bodyweight, a finding that may reflect both an adolescent's genetic predisposition to overweight as well as parental behavior and attitudes regarding nutrition and the value of physical exercise and recreation. We found evidence that greater parental educational attainment was associated with a reduced likelihood of male adolescent overweight, and that parental smoking behavior (for both male and female adolescents) was associated with an increased likelihood of adolescent overweight. By contrast, we found little evidence that parental employment status measured at a point in time contributed to this outcome.

Our results for geographic and neighborhood characteristics varied considerably and were not always in the expected direction for both genders. We found that unsafe neighborhoods were related to an increased likelihood that a female adolescent would be overweight and that neighborhoods of poor quality increased the likelihood of both male and female overweight. The greater availability of fresh food stores reduced the likelihood of male overweight, while more snack food outlets increased the likelihood of male overweight and the likelihood that a female would be at risk for overweight or overweight. Finally, for males, we find some evidence that higher full-service restaurant prices reduced bodyweight and that higher cigarette prices increased BMI levels.

These findings suggest that targeting educational efforts at parents who are obese or at risk for obesity as well as those who engage in poor health habits such as smoking may have implications for the bodyweight of their children. Additionally, making nutritious food outlets more widely available might also have an ameliorative effect. Our expenditure results suggest that such interventions could yield cost savings from reduced medical expenditures, not just in the future when some of these children become obese adults with costly medical conditions, but in the short term during their adolescence.

Finally, our finding that female adolescents who are overweight or at risk for overweight incur higher mental health expenditures than those of normal weight points to the need for a better understanding of the nature of causality between adolescent mental health problems and overweight and its implications for health expenditures. Such an understanding is essential to identify the specific channels through which overweight in female adolescents contributes to an increase in health care spending. Other research that focuses on the type and intensity of health care use by overweight adolescents can also contribute to understanding expenditure differentials by bodyweight class.

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Table 1. Comparison of MEPS (2001-2003) and NHANES (1999-2002) Estimates of Adolescent Overweight by Gender and Race/Ethnicity.

	MEPS	NHANES
All adolescents (ages 12-19)	14.2* (0.5)	16.1 (0.8)
Males	15.8 (0.7)	16.7 (0.9)
Females	12.5* (0.7)	15.4 (1.2)
White (non-Hispanic)		
Males	12.8 (1.2)	14.6 (1.3)
Females	9.9 (1.2)	12.7 (1.8)
Black (non-Hispanic)		
Males	18.0 (2.6)	18.7 (1.7)
Females	23.5 (2.9)	23.6 (1.8)

Standard errors in parenthesis. * Significantly different at $p < 0.05$ for a two-tailed test.

Table 2. Estimates from models of adolescent overweight: males			
	BMI (1)	**At risk/Overweight (2)**	**Overweight (3)**
Age	0.478***	-0.068***	-0.060***
	(0.043)	(0.013)	(0.015)
Hispanic	1.080***	0.313***	0.274**
	(0.298)	(0.089)	(0.106)
Black	0.098	-0.013	0.029
	(0.325)	(0.093)	(0.090)
Other race	0.544	0.142	0.034
	(0.604)	(0.207)	(0.227)
Asian	0.355	0.213	0.184
	(0.409)	(0.131)	(0.161)
Mom under weight	-1.851***	-0.366	-0.556**
	(0.428)	(0.241)	(0.264)
Mom at risk for obesity	0.823***	0.318***	0.204**
	(0.201)	(0.075)	(0.087)
Mom is obese	2.321***	0.638***	0.583***
	(0.240)	(0.072)	(0.082)
Mom BMI is missing	1.223**	0.374*	0.398
	(0.596)	(0.205)	(0.252)
Mom smokes	0.643**	0.163**	0.159*
	(0.263)	(0.074)	(0.084)
Mom education missing	0.725	0.078	0.098
	(1.841)	(0.345)	(0.400)
Mom High School Only	-0.300	-0.046	-0.051
	(0.401)	(0.104)	(0.131)
Mom Some College	-0.801*	-0.181	-0.282*
	(0.451)	(0.126)	(0.150)
Mom College	-0.325	-0.044	-0.079
	(0.497)	(0.143)	(0.168)
Two parent family	1.656	0.348	0.343
	(2.093)	(0.557)	(0.550)
Dad education missing	-0.143	-0.023	0.170
	(1.938)	(0.494)	(0.459)
Dad high school only	-1.367***	-0.247**	-0.382***
	(0.440)	(0.109)	(0.144)

Table 2 (continued). Estimates from models of adolescent overweight: males			
Dad some college	-1.398**	-0.320**	-0.395**
	(0.544)	(0.142)	(0.171)
Dad College	-1.250**	-0.291**	-0.376**
	(0.494)	(0.141)	(0.171)
Dad smokes	0.210	0.078	0.096
	(0.303)	(0.092)	(0.102)
Dad underweight	6.047*	1.055	0.912
	(3.327)	(0.671)	(0.652)
Dad at risk for obesity	0.666***	0.262***	0.139
	(0.242)	(0.086)	(0.099)
Dad is obese	1.523***	0.451***	0.324***
	(0.317)	(0.097)	(0.116)
Dad BMI missing	1.249	0.435	-0.034
	(0.918)	(0.268)	(0.335)
Mom works < 35 hours	-0.856***	-0.245**	-0.158
	(0.310)	(0.096)	(0.102)
Mom works 35+ hours	-0.429	-0.148*	-0.028
	(0.284)	(0.082)	(0.083)
Dad is employed	-0.362	-0.014	-0.052
	(0.384)	(0.111)	(0.126)
Mom in fair/poor health	0.218	0.019	0.099
	(0.348)	(0.085)	(0.091)
Dad in fair/poor health	-0.443	-0.047	-0.159
	(0.373)	(0.104)	(0.123)
Low Income	0.560	0.102	0.123
	(0.371)	(0.092)	(0.092)
Middle Income	0.291	0.054	0.027
	(0.337)	(0.094)	(0.104)
High Income	0.465	0.230**	-0.001
	(0.338)	(0.101)	(0.119)
Family size	-0.227***	-0.045**	-0.067***
	(0.062)	(0.019)	(0.024)
Midwest	-0.173	-0.070	-0.046
	(0.373)	(0.128)	(0.138)
West	-0.374	-0.033	-0.135
	(0.376)	(0.134)	(0.139)
South	0.556	0.186	0.123
	(0.379)	(0.131)	(0.157)
MSA (1 = yes)	-0.034	-0.056	-0.105
	(0.277)	(0.092)	(0.100)
Population Density	-4.42e-06	-1.92e-06	-1.76e-07
	(1.31e-05)	(3.27e-06)	(3.70e-06)

Table 2 (continued). Estimates from models of adolescent overweight: males			
Population Density is missing (1 = yes)	0.104	-0.031	-0.231
	(0.574)	(0.213)	(0.209)
Limited service restaurant price	11.112*	2.056	2.866
	(6.410)	(2.173)	(2.537)
Full service restaurant price	-1.260**	-0.407**	-0.076
	(0.586)	(0.189)	(0.219)
Limited service restaurant price squared	-0.855*	-0.153	-0.224
	(0.506)	(0.172)	(0.201)
Full service restaurant price squared	0.051**	0.017**	0.003
	(0.024)	(0.008)	(0.009)
Junk food/convenience stores	2.119*	0.433	0.991**
	(1.232)	(0.400)	(0.430)
Fresh food outlets	-6.802	-1.286	-3.719**
	(4.517)	(1.710)	(1.868)
Limited service restaurants	0.064	0.057	0.083
	(0.770)	(0.246)	(0.287)
Full service restaurants	-0.201	-0.113	0.059
	(0.379)	(0.134)	(0.142)
Cigarette Price	0.004*	0.001	0.001
	(0.002)	(0.001)	(0.001)
Crime data missing (1 = yes)	0.129	0.028	0.064
	(0.617)	(0.189)	(0.179)
Assaults - second quartile	0.042	-0.022	0.104
	(0.284)	(0.092)	(0.107)
Assaults - third quartile	-0.148	-0.098	-0.053
	(0.292)	(0.102)	(0.110)
Assaults - fourth quartile	-0.385	-0.086	-0.112
	(0.311)	(0.106)	(0.120)
Murder - second quartile	-0.220	-0.033	-0.129
	(0.272)	(0.090)	(0.111)

Table 2 (continued). Estimates from models of adolescent overweight: males			
Murder - third quartile	0.110	0.028	0.033
	(0.307)	(0.097)	(0.116)
Murder - fourth quartile	0.016	-0.005	-0.066
	(0.328)	(0.108)	(0.123)
% on public assistance	2.048	0.695	1.753*
	(3.156)	(0.933)	(0.952)
Median value of housing	2.26e-07	-7.63e-09	-1.20e-07
	(1.33e-06)	(4.86e-07)	(5.52e-07)
Vacancy rates	1.021	-0.127	0.034
	(1.555)	(0.495)	(0.578)
Year 2	-0.112	-0.111	-0.024
	(0.222)	(0.070)	(0.075)
Year 3	0.125	0.018	-0.073
	(0.203)	(0.068)	(0.069)
Constant	-15.470	-4.584	-9.087
	(20.031)	(6.811)	(7.807)
Observations	3463	3463	3463
R-squared	.1635		
Pseudo R-squared		.0792	.0928

Source: Medical Expenditure Panel Survey 2001-2003.
*, **, *** indicate statistical significance at the 10, 5 and 1 percent levels respectively. Standard errors are in parentheses.

Table 3. Estimates from models of adolescent overweight: females			
	BMI (1)	**At risk/Overweight (2)**	**Overweight (3)**
Age	0.360***	-0.066***	-0.071***
	(0.043)	(0.015)	(0.017)
Hispanic	0.678**	0.154*	0.167
	(0.298)	(0.089)	(0.104)
Black	1.324***	0.192*	0.260**
	(0.489)	(0.104)	(0.132)
Other race	0.450	-0.052	0.222
	(0.673)	(0.219)	(0.227)
Asian	-0.851*	-0.219	-0.352
	(0.482)	(0.185)	(0.234)
Mom under weight	1.512	0.239	0.615**
	(2.219)	(0.286)	(0.308)
Mom at risk for obesity	0.801***	0.214**	0.225**
	(0.211)	(0.086)	(0.108)
Mom is obese	2.965***	0.752***	0.742***
	(0.273)	(0.081)	(0.092)
Mom BMI is missing	3.413***	0.804***	0.818***
	(1.215)	(0.188)	(0.235)
Mom smokes	0.527*	0.165*	0.136
	(0.313)	(0.090)	(0.100)
Mom education missing	-0.000	0.042	-0.112
	(1.549)	(0.501)	(0.447)
Mom High School Only	-0.405	-0.115	-0.106
	(0.442)	(0.117)	(0.146)
Mom Some College	-0.601	-0.116	-0.106
	(0.525)	(0.137)	(0.169)
Mom College	-0.444	-0.132	-0.050
	(0.554)	(0.156)	(0.173)
Two parent family	1.343	0.729*	0.291
	(2.215)	(0.440)	(0.454)
Dad education missing	1.467	0.326	0.398
	(1.946)	(0.359)	(0.370)
Dad high school only	0.283	-0.029	0.017
	(0.433)	(0.126)	(0.139)
Dad some	-0.128	-0.147	-0.122

Table 3. Estimates from models of adolescent overweight: females			
	BMI (1)	**At risk/Overweight (2)**	**Overweight (3)**
college			
	(0.591)	(0.153)	(0.173)
Dad College	-0.007	-0.098	-0.205
	(0.517)	(0.163)	(0.181)
Dad smokes	0.755**	0.247***	0.223**
	(0.342)	(0.093)	(0.105)
Dad underweight	2.425*	1.067***	0.630
	(1.340)	(0.394)	(0.506)
Dad at risk for obesity	0.994***	0.304***	0.307**
	(0.278)	(0.112)	(0.141)
Dad is obese	1.681***	0.491***	0.436***
	(0.297)	(0.114)	(0.155)
Dad BMI missing	0.932	0.588**	0.103
	(0.960)	(0.292)	(0.355)
Mom works < 35 hours	-0.240	0.053	-0.016
	(0.268)	(0.089)	(0.115)
Mom works 35+ hours	0.304	0.099	0.075
	(0.265)	(0.078)	(0.089)
Dad is employed	-0.353	-0.113	-0.084
	(0.529)	(0.143)	(0.152)
Mom in fair/poor health	0.742	0.078	0.213*
	(0.461)	(0.099)	(0.116)
Dad in fair/poor health	0.368	-0.075	0.108
	(0.637)	(0.150)	(0.157)
Low Income	-0.256	-0.044	-0.184
	(0.370)	(0.107)	(0.118)
Middle Income	0.175	-0.029	-0.040
	(0.369)	(0.108)	(0.125)
High Income	0.081	-0.086	-0.087
	(0.396)	(0.127)	(0.137)
Family size	-0.163**	-0.064**	-0.045
	(0.080)	(0.025)	(0.031)
Midwest	-0.217	-0.261*	-0.088
	(0.524)	(0.135)	(0.165)
West	-0.231	-0.265*	-0.171
	(0.527)	(0.149)	(0.171)
South	-0.427	-0.314**	-0.227
	(0.544)	(0.141)	(0.173)
MSA (1 = yes)	-0.131	-0.217**	-0.099

Table 3. Estimates from models of adolescent overweight: females			
	BMI (1)	**At risk/Overweight (2)**	**Overweight (3)**
	(0.425)	(0.101)	(0.117)
Population Density	-1.65e-05*	-2.82e-06	-3.37e-06
	(9.13e-06)	(3.29e-06)	(3.96e-06)
Population Density is missing (1 = yes)	-0.605	-0.364	-0.132
	(0.890)	(0.336)	(0.339)
Limited service restaurant price	11.381	1.237	6.840**
	(8.081)	(2.481)	(3.470)
Full service restaurant price	0.443	0.304	0.059
	(0.805)	(0.219)	(0.241)
Limited service restaurant price squared	-0.873	-0.096	-0.536*
	(0.627)	(0.195)	(0.276)
Full service restaurant price squared	-0.014	-0.010	0.001
	(0.033)	(0.009)	(0.010)
Junk food/convenience stores	0.732	1.000**	0.321
	(1.466)	(0.434)	(0.484)
Fresh food outlets	7.302	1.744	1.331
	(8.314)	(1.996)	(2.290)
Limited service restaurants	0.934	0.289	0.359
	(1.025)	(0.266)	(0.358)
Full service restaurants	-0.924**	-0.383***	-0.442**
	(0.446)	(0.141)	(0.185)
Cigarette Price	-0.005	-0.001	-0.003**
	(0.003)	(0.001)	(0.001)
Crime data missing (1 = yes)	0.996	-0.062	0.194
	(1.290)	(0.160)	(0.184)
Assaults - second quartile	0.139	0.111	0.115
	(0.394)	(0.111)	(0.133)
Assaults - third quartile	-0.199	0.078	0.023

Table 3. Estimates from models of adolescent overweight: females			
	BMI (1)	**At risk/Overweight (2)**	**Overweight (3)**
	(0.388)	(0.123)	(0.146)
Assaults - fourth quartile	-0.269	-0.030	-0.004
	(0.452)	(0.133)	(0.150)
Murder - second quartile	0.488	0.198*	0.181
	(0.341)	(0.102)	(0.123)
Murder - third quartile	0.557	0.095	0.230*
	(0.425)	(0.109)	(0.131)
Murder - fourth quartile	0.319	0.267**	0.301**
	(0.358)	(0.120)	(0.137)
% on public assistance	3.780	-0.335	0.197
	(2.798)	(0.788)	(0.863)
Median value of housing	-8.11e-07	1.04e-06**	9.65e-08
	(1.34e-06)	(5.07e-07)	(5.33e-07)
Vacancy rates	2.723	0.676	1.240*
	(1.848)	(0.512)	(0.649)
Year 2	0.302	0.019	-0.038
	(0.243)	(0.069)	(0.083)
Year 3	0.454**	0.033	-0.011
	(0.227)	(0.066)	(0.074)
Constant	-25.124	-5.996	-22.405**
	(23.848)	(7.617)	(10.636)
Observations	3275	3275	3275
R-squared	.1636		
Pseudo R-squared		.1304	.1441

Source: Medical Expenditure Panel Survey 2001-2003.
*, **, *** indicate statistical significance at the 10, 5 and 1 percent levels respectively. Standard errors are in parentheses.

Table 4. Estimates from Expenditure Models				
	Males		Females	
	Probit	GLM	Probit	GLM
Child is overweight	-0.043	0.093	0.215**	0.445***
	(0.091)	(0.098)	(0.096)	(0.148)
Child is at risk for /overweight	-0.087	0.164	-0.064	0.314**
	(0.086)	(0.101)	(0.090)	(0.122)
Child is underweight	-0.004	0.161	-0.459***	0.267
	(0.176)	(0.214)	(0.173)	(0.206)
Insured all year	0.879***	0.865***	0.653***	0.191
	(0.096)	(0.160)	(0.106)	(0.162)
Insured part year	0.614***	0.543***	0.551***	0.029
	(0.117)	(0.202)	(0.126)	(0.140)
Age	-0.063***	-0.017	-0.007	0.009
	(0.016)	(0.016)	(0.015)	(0.015)
Two parent family	0.513	-0.231	0.250	-1.078***
	(0.415)	(0.824)	(0.656)	(0.229)
Hispanic	-0.211**	-0.222**	-0.502***	-0.269*
	(0.101)	(0.101)	(0.100)	(0.153)
Black	-0.541***	-0.401***	-0.886***	-0.348
	(0.096)	(0.119)	(0.124)	(0.218)
Asian	-0.164	-0.638***	-0.426**	-0.262*
	(0.184)	(0.161)	(0.178)	(0.156)
Other race	-0.002	0.330	-0.285	-0.571***
	(0.220)	(0.318)	(0.359)	(0.219)
Low income	0.091	-0.012	-0.120	0.010
	(0.105)	(0.145)	(0.091)	(0.118)
Middle income	0.134	0.121	0.035	0.316**
	(0.105)	(0.126)	(0.102)	(0.134)
High income	0.166	0.290*	0.186	0.486***
	(0.142)	(0.151)	(0.125)	(0.136)
MSA	-0.085	-0.135	0.083	0.081
	(0.094)	(0.109)	(0.085)	(0.113)
Midwest	-0.016	0.048	-0.055	0.453***
	(0.119)	(0.108)	(0.135)	(0.108)
West	-0.322***	-0.286**	-0.305**	0.125
	(0.122)	(0.129)	(0.118)	(0.087)
South	-0.110	-0.102	-0.140	0.199**
	(0.099)	(0.130)	(0.113)	(0.098)
Mom smokes	-0.162*	-0.060	-0.114	0.019
	(0.092)	(0.100)	(0.091)	(0.075)
Mom education missing	-0.459	1.195**	-0.758	0.020
	(0.333)	(0.503)	(0.508)	(0.520)

Table 4. Estimates from Expenditure Models				
	Males		Females	
	Probit	GLM	Probit	GLM
Mom - high school only	0.122	0.339*	0.315**	0.457***
	(0.128)	(0.205)	(0.159)	(0.171)
Mom - some college	0.276*	0.232	0.263	0.478**
	(0.144)	(0.212)	(0.194)	(0.233)
Mom - college	0.388**	0.555***	0.359*	0.545**
	(0.165)	(0.198)	(0.183)	(0.213)
Dad smokes	-0.112	0.143	-0.194*	-0.294**
	(0.103)	(0.128)	(0.108)	(0.130)
Dad employed	0.037	-0.135	-0.065	-0.190
	(0.127)	(0.168)	(0.135)	(0.175)
Mom works part time	0.155	-0.084	0.111	-0.103
	(0.109)	(0.131)	(0.106)	(0.098)
Mom works full time	0.001	-0.181*	0.067	-0.254**
	(0.094)	(0.099)	(0.083)	(0.107)
Dad education missing	0.401	-0.122	0.305	-1.092***
	(0.405)	(0.797)	(0.632)	(0.274)
Dad high school only	-0.042	-0.116	0.235	0.340**
	(0.137)	(0.279)	(0.149)	(0.171)
Dad some college	-0.097	0.023	0.336*	0.281
	(0.159)	(0.310)	(0.197)	(0.200)
Dad college	0.101	0.136	0.257	0.080
	(0.182)	(0.282)	(0.162)	(0.174)
Family size	-0.113***	0.050	-0.122***	-0.006
	(0.024)	(0.044)	(0.023)	(0.031)
Year Two	-0.081	-0.096	0.275***	0.008
	(0.094)	(0.120)	(0.091)	(0.095)
Year Three	-0.080	0.042	0.186**	-0.120
	(0.090)	(0.116)	(0.087)	(0.086)
Hospital Wage Index	--	0.815**	--	0.481
		(0.326)		(0.294)
Constant	1.318**	5.874***	0.814	6.796***
	(0.534)	(0.740)	(0.715)	(0.618)
Observations	3463	2708	3275	2711
Pseudo R-Squared	.1436		.1740	

Source: Medical Expenditure Panel Survey 2001-2003.
*, **, *** indicate statistical significance at the 10, 5 and 1 percent levels respectively. Standard errors are in parentheses.

Table 5: Sensitivity of female expenditure differentials to alternative strategies		
	Expenditure Differentials	
	Overweight vs. normal weight	**At risk for overweight vs. normal weight**
No health conditions	$790 (315)	$467 (242)
Strategy:		
Add weight-related conditions	$660 (301)	$252 (175)
Expenditures net of mental health spending (no conditions)	$622 (278)	$68 (118)
Mental health expenditures	$208 (91)	$286 (131)

Source: Medical Expenditure Panel Survey 2001-2003.

Appendix Table A: Means and Standard Deviations of Independent Variables

Variable	Female		Male	
	Mean	Standard Deviation	Mean	Standard Deviation
Age	15.386	2.242	15.371	2.255
Hispanic	0.147		0.144	
Black	0.131		0.135	
Other race	0.021		0.022	
Asian	0.044		0.043	
Mom under weight	0.019		0.016	
Mom at risk for obesity	0.278		0.272	
Mom is obese	0.289		0.280	
Mom BMI is missing	0.025		0.027	
Mom smokes	0.204		0.219	
Mom education missing	0.003		0.003	
Mom High School Only	0.457		0.445	
Mom Some College	0.245		0.244	
Mom College	0.237		0.241	
Two parent family	0.748		0.758	
Dad education missing	0.256		0.244	
Dad high school only	0.310		0.336	
Dad some college	0.154		0.163	
Dad College	0.229		0.212	
Dad smokes	0.160		0.161	
Dad underweight	0.001		0.001	
Dad at risk for obesity	0.355		0.358	
Dad is obese	0.211		0.216	
Dad BMI missing	0.261		0.252	
Mom works < 35 hours	0.208		0.194	
Mom works 35+ hours	0.538		0.563	
Dad is employed	0.681		0.684	
Mom in fair/poor health	0.116		0.108	
Dad in fair/poor health	0.065		0.078	
Low Income	0.120		0.130	
Middle Income	0.336		0.358	
High Income	0.378		0.338	
Family size	4.335	1.453	4.375	1.449
Midwest	0.243		0.238	
West	0.228		0.228	
South	0.342		0.355	
MSA	0.827		0.810	
Population Density	4598.180	11637.610	4277.030	10345.750
Population Density is missing (1 = yes)	0.006		0.008	
Limited service restaurant price	6.186	0.390	6.182	0.396
Full service restaurant	11.332	1.933	11.277	1.908

Appendix Table A: Means and Standard Deviations of Independent Variables

Variable	Female		Male	
	Mean	Standard Deviation	Mean	Standard Deviation
price				
Junk food/convenience stores	0.188	0.094	0.187	0.093
Fresh food outlets	0.018	0.021	0.018	0.022
Limited service restaurants	0.658	0.150	0.653	0.164
Full service restaurants	0.657	0.308	0.651	0.278
Cigarette Price	390.638	64.238	390.462	63.432
Crime data missing (1 = yes)	0.031		0.039	
Assaults - second quartile	0.249		0.229	
Assaults - third quartile	0.239		0.248	
Assaults - fourth quartile	0.240		0.241	
Murder - second quartile	0.233		0.241	
Murder - third quartile	0.246		0.249	
Murder - fourth quartile	0.248		0.228	
% on public assistance	0.034	0.042	0.036	0.040
Median value of housing	139340.900	103614.200	130236.600	86119.140
Vacancy rates	0.067	0.061	0.069	0.062
Year 2	0.340		0.341	
Year 3	0.336		0.334	