# WHAT IS THE ECONOMIC COST OF OVERWEIGHT CHILDREN?

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## INTRODUCTION

The increase in childhood obesity in the past two decades has been declared an epidemic in the medical and the popular press [Strauss and Pollack, 2001; Olson, 2002]. The consequences of this epidemic in terms of health outcomes are not well understood, but an emerging clinical literature is finding links between obesity and a variety of diseases and chronic conditions in children.

One way to measure the magnitude of this purported epidemic is to calculate its cost in dollars. A recent study reports that obesity in adults increases medical expenditures dramatically: inpatient and outpatient spending is estimated to increase by 33 percent, spending on medications by 77 percent [Sturm, 2002]. The only pediatric estimate to date calculates the increase in hospital expenditures attributable to a diagnosis of obesity and three obesity related illnesses [Wang and Dietz, 2002]. This study finds that pediatric obesity costs $127 million annually and, perhaps more alarmingly, this represents an increase of over 300 percent between 1979-1981 and 1997-1999. Furthermore, this is a conservative estimate of the total cost of obesity because the analysis is limited to hospital costs and because many conditions related to obesity were excluded.

We use a different technique and data set to obtain a more comprehensive estimate of the total cost of childhood obesity, and we reach a much different conclusion. Our broader approach has several advantages. First, we do not restrict attention solely to diseases shown to be caused by obesity. The number of diagnoses shown to be related to obesity in children has been increasing as obesity has received increasing attention. Overweight children are at risk for increased stress of weight bearing joints [Bray, 1985], hyperinsulimia and type 2 diabetes [Pinhas-Hamiel et al., 1996; Freedman et al., 1999], hypertension and dyslipidemia [Figueroa-Colon et al., 1997; Morrison et al. 1999 a/b; Freedman et al., 1999], gallbladder disease [Schweizer, Lenz, and

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Kirschner, 2000], sleep apnea, Pickwickian syndrome or breathing difficulties [Leung and Robson, 1990] and metabolic syndrome, which includes hypertension, dyslipidemia, insulin resistance [Vanhala et al., 1999]. In addition, overweight is a risk-factor for childhood asthma which is the principal cause of chronic illness in children [Rodriguez, et al., 2002; Cypcar and Lemanski, 1994]. Our estimates also allow for the possibility that obesity may cause the treatment costs to be higher for any medical condition, even if obesity did not cause the condition that led to the medical intervention. Moreover, our approach allows for the possibility that obesity may reduce the occurrence or cost of some conditions. It is possible that overweight children are more robust when confronting childhood ailments that result in rapid weight loss or there may be other less obvious effects. In adults, for example, obesity may reduce bone density loss and osteoporosis [Albala et al., 1996]. Although the effects for children are not known, it is important to allow for this possibility.

A second advantage of our approach is that we model medical expenditures directly rather than estimating differences in utilization. Our approach allows us to include controls for demographic and socio-economic variables that may explain some differences in health expenditures that are not caused by obesity. Wang and Dietz [2002] estimate utilization differences in diagnoses and do not control for demographics because of the small number of obesity-related diagnoses observed in their data.

Perhaps the most important advantage of our approach is that we calculate and report confidence intervals for our cost estimate. Previous estimates of obesity attributable costs do not present any measure of uncertainty associated with their estimates [Sturm, 2002; Wang and Dietz, 2002]. Because we use a two-equation model for health expenditures, we use bootstrap methods to obtain estimates of the confidence intervals. Our estimates show that confidence intervals can be large and include zero even when the underlying regressions show significant effects of the variable of interest.

We believe a careful re-examination of these cost estimates has important implications for policy makers and parents concerned about the rapid rise in childhood obesity. Myopically focusing on potentially insignificant short-term costs may divert attention from the potential long-term costs. The true cost of childhood obesity may be increased likelihood of adult obesity. If parents and policy makers are told to expect obese children to be unhealthy, they may be lulled into a false sense of security when they find these children are not much sicker than their non-overweight counterparts.

This paper presents estimates of the effects of childhood overweight on children's prescription drug, in-patient and office based health expenditures for children ages 4 to 17 using the 1998 Medical Expenditure Panel Survey. We know that in the coming decades, absent a successful intervention that breaks the link between childhood overweight and adult obesity, medical expenditures are likely to rise substantially as overweight children become obese adults [Whitaker et al., 1997; Guo et al., 2002]. This paper focuses on the near term impact on medical expenditures from the epidemic increase in childhood overweight. First, we identify the conditions that affect children's health care costs by frequency of diagnosis and percentage of overall expenditures for overweight and non-overweight children. Second, we estimate the obesity attributable fraction (OAF) of total medical expenditures controlling for other factors that may cause health care expenditures to differ.

## DATA AND METHODS

***Data.*** Data for children between 4 and 17 years of age from the 1998 Medical Expenditure Panel Survey (MEPS) were analyzed. The MEPS is a nationally representative sample of the U.S. noninstitutionalized civilian population conducted by the Agency for Healthcare Research Quality. The MEPS provides data on health care services use, expenditures and source of payment as well as data on the individual's economic, demographic, family, and other characteristics.

***Overweight.*** The body mass index, the weight in kilograms divided by the height in meters squared (BMI), is the preferred screen for overweight in population-based studies for both adults and children [Cole, 1991; Dietz and Bellizzi, 1999]. For adults, specific BMI cut-off values for determining obesity and overweight have been established based on increased occurrence of chronic disease [Kuczmarski and Flegal, 2000], but the amount of body fat constituting obesity in children has not yet been determined. Instead, the recommended cutoff values for pediatric overweight are based on percentile values from the 2000 US pediatric growth charts from the Centers for Disease Control and Prevention and National Center for Health Statistics. These growth charts are based on physical measurements taken from the National Health Examination Surveys from 1963-1965 and 1966-1970 (NHES II and III) and the National Health and Nutrition Examination Surveys from 1971-1974 and 1976-1979 (NHANES I and II).

A child is considered overweight if the BMI-for-age-and-gender is greater than or equal to the 95$^{th}$ percentile. If the BMI-for-age-and-gender is between the 85$^{th}$ and 95$^{th}$ percentile, the child is considered "at risk for overweight" [Barlow and Dietz, 1998]. The growth charts excluded more recent data from NHANES III (1988-1994) in order to avoid the influence of an increase in BMI that occurred between NHANES II and III. Thus, when we examine BMI for children using more recent data we have the seeming "paradox" that more than 5 percent of children are in the 95$^{th}$ percentile of the growth chart and classified as overweight. For example, between 1988-1994, 13.6 percent of children between 6 and 11 years of age are in the 95 percent of the growth chart and classified as overweight [Health United States, 1998].

Because the use of these cutoffs could be viewed as controversial, we report our main results for two measures of excess weight in children: overweight and "at risk", where "at risk" includes children who are classified as overweight or at risk for overweight. That is, the "at risk" group includes all children with a BMI above the 85$^{th}$ percentile. The current use of BMI cutoffs is well established for adults, but there is still some controversy—especially for adults with larger muscle mass who report a high BMI without having a high percentage of body fat or those with BMI $<30$ kg/m$^2$ [Frankenfield et al., 2001]. For children, a similar concern arises in that we may not be able to distinguish between "overweight" versus "above the normal growth". In addition, the BMI percentiles may not correspond to percent body fat in children. A previous study found that the 95$^{th}$ percentile BMI cutoffs for children and adolescents developed from the 1980 NHANES provided adequate screening for excess adipose (or fat) tissue [Lazarus et al., 1996]; yet no study has studied the recent BMI measures.

The 1998 MEPS data for children, including height and weight, were reported by the parent or guardian who responded to the survey. The accuracy of such parental reports is not known, and an examination of the weight data reveals clustering at 5 pound intervals. The literature on self-reported heights and weights for adults and adolescents consistently finds that heights tend to be overstated while weights tend to be underestimated [Spencer et al., 2002; Strauss, 1999; Palta et al., 1982], and there are suggested methods of correction of these biases [Cawley, 1999]. If the same biases occur in parental reports for children, then the BMI from MEPS would be understated. Unfortunately, no correction methods are available for correcting parent reports. Although we cannot gauge the accuracy of the BMI in our data, the demographic patterns in our data are roughly consistent with results from two data sets in which height and weight were measured: the National Longitudinal Survey of Youth (NLSY) and NHANES III (1988-1994). Consistent with Strauss and Pollack's [2001] findings from the NLSY for 1998, our results show that the prevalence of overweight is higher among boys, residents in southern states, Hispanics, and African Americans (see Table 1). The prevalence of overweight in our sample is higher than found in NHANES III [Health United States, 1998] which is expected given the increase in the percentage overweight over time, and both data sets show that the percent overweight decreases with age. After excluding twenty-six observations with implausibly extreme BMI values (BMI > 50 or BMI < 11), our data has observations on 4898 children representing a population size of 50,315,993.

**TABLE 1**
**Sample Means (using population weights)**

| | Full Sample n = 4898* | Non-Overweight | Overweight | t-test for difference in Means |
|---|---|---|---|---|
| Overweight | 0.204 | | | |
| | (0.008) | | | |
| At-Risk | 0.353 | | | |
| | (0.010) | | | |
| Underweight | 0.073 | | | |
| | (0.005) | | | |
| Age | 10.583 | 11.018 | 8.888 | -11.147 |
| | (0.081) | (0.087) | (0.170) | |
| Male | 0.511 | 0.490 | 0.593 | 5.018 |
| | (0.009) | (0.010) | (0.018) | |
| Mother's Age | 37.642 | 38.162 | 35.577 | -7.169 |
| | (0.165) | (0.179) | (0.313) | |
| Mother Married | 0.750 | 0.774 | 0.652 | -4.990 |
| | (0.012) | (0.013) | (0.021) | |
| Mother's Education | 13.110 | 13.253 | 12.542 | -4.703 |
| | (0.078) | (0.081) | (0.127) | |
| Black | 0.163 | 0.144 | 0.240 | 4.150 |
| | (0.124) | (0.012) | (0.020) | |
| American Indian | 0.008 | 0.009 | 0.006 | -0.824 |
| | (0.002) | (0.002) | (0.002) | |
| Asian | 0.040 | 0.040 | 0.041 | 0.150 |
| | (0.005) | (0.005) | (0.011) | |

**TABLE 1—*Continued***
**Sample Means (using population weights)**

| | Full Sample n = 4898* | Non-Overweight | Overweight | t-test for difference in Means |
|---|---|---|---|---|
| Hispanic | 0.133 | 0.118 | 0.190 | 4.332 |
| | (0.008) | (0.008) | (0.015) | |
| South | 0.343 | 0.329 | 0.398 | 2.278 |
| | (0.015) | (0.015) | (0.027) | |
| West | 0.231 | 0.237 | 0.210 | -1.074 |
| | (0.014) | (0.016) | (0.020) | |
| Northeast | 0.175 | 0.174 | 0.176 | 0.094 |
| | (0.014) | (0.014) | (0.022) | |
| Midwest | 0.252 | 0.261 | 0.216 | -1.654 |
| | (0.013) | (0.013) | (0.024) | |
| Public Insurance | 0.173 | 0.150 | 0.262 | 4.898 |
| | (0.011) | (0.010) | (0.020) | |
| Private Insurance | 0.733 | 0.757 | 0.640 | 4.770 |
| | (0.012) | (0.012) | (0.021) | |
| Income Category 1 | 0.167 | 0.154 | 0.217 | 3.152 |
| | (0.009) | (0.009) | (0.017) | |
| Income Category 2 | 0.048 | 0.045 | 0.058 | 1.134 |
| | (0.005) | (0.006) | (0.009) | |
| Income Category 3 | 0.136 | 0.124 | 0.183 | 3.268 |
| | (0.008) | (0.008) | (0.016) | |
| Income Category 4 | 0.357 | 0.360 | 0.342 | -0.750 |
| | (0.011) | (0.011) | (0.022) | |
| Income Category 5 | 0.292 | 0.316 | 0.200 | -5.120 |
| | (0.013) | (0.014) | (0.018) | |
| Limited Activity | 0.029 | 0.029 | 0.026 | -0.486 |
| | (0.003) | (0.004) | (0.006) | |
| Had Medical Expenditure | 0.714 | 0.710 | 0.731 | 1.139 |
| | (0.009) | (0.011) | (0.016) | |
| Medical Expenditure | 493.388 | 494.558 | 488.827 | -5.732 |
| | (28.989) | (33.564) | (62.500) | |

* Represents a population size of 50,315,993. Standard errors are in parentheses.

***Overweight Attributable Fraction.*** Our objective is to determine how much more is spent on health care for children who are overweight in comparison to children who are not overweight, after controlling for other differences in these populations. This empirical question is similar to the one raised in the public health literature in estimating the costs of smoking, and our methods follow those developed in that literature. These methods have evolved from disease-by-disease estimation of the proportion of each disease caused by smoking to a comprehensive multi-equation econometric model of medical expenditures in which all disease categories are included (for a review of the earlier literature, see Warner, Hodgson, and Carroll [1999], Coller, Harrison, and McInnes [2002], and Miller et al. [1998 a and b]). Because obesity, like smoking, appears to have broad affects on health and also because we do not wish to impose assumptions *a priori* about those affects, a similar econometric model to that developed in the literature on estimating the costs of smoking is appropriate. Alternatively we could have used generalized linear methods suggested by Manning and Mullahy [2001] but choose the specification common in the smoking literature to make our results more comparable.

We estimate a model of medical expenditures that allows us to determine the effects of overweight. Then, for each child, we calculate the Overweight Attributable Fraction (OAF) of healthcare expenditures as:

$$OAF_i = \frac{(EXPO_i) - (EXPNO_i)}{(EXPNO_i)},$$

where $EXPO_i$ is the predicted level of expenditures given individual *i*'s actual weight and $EXPNO_i$ is the predicted level of expenditures if individual *i* were not overweight. For children who are overweight, the sign of $OAF_i$ will depend on the predicted marginal effect of being overweight for that child. For children who are not overweight, the $OAF_i$ is zero by construction. We calculate the $OAF_i$ for each child and then the population OAF is calculated by averaging over the population of children. Because the OAF reflects both the prevalence and severity of overweight, it is a useful metric of the effects of the condition at the level of the population.

To estimate medical expenditures, we use a hurdle model that consists of two equations. The first equation estimates the probability of having a medical expenditure, and the second estimates the level of expenditure (in logs) conditional on the expenditure being positive. This model allows excess weight to affect health expenditures through two pathways. First, as discussed in the introduction, obesity is associated with a host of diseases and chronic conditions. Second, overweight may increase the cost of treating conditions that are not directly caused by overweight. For example, because overweight children are at higher risk for conditions that affect the respiratory system, there can exist increased treatment costs for injuries from a car accident. Such two-part models are commonly used to model health expenditures. Estimated health expenditures with a single OLS equation may result in biased coefficients because of the cluster at zero expenditures [Manning and Mullahy, 2001]. We estimate a two-part model with medical expenditures in the second part to account for the clustering at zero as well ask the skewness in the distribution.

Using the estimated model, we then calculate for each child *EXPOi* as the product of the predicted probability having an expenditure given the child's characteristics and the predicted expenditure conditional on the expenditure being positive. The calculation for $EXPNO_i$ is the same except the indicator for overweight is set to zero. In estimating the model, all expenditures associated with inpatient visits, emergency room visits, outpatient visits, office based visits and prescription drugs were included. Because the distribution of expenditures is skewed to the right, the expenditures are logged for the regression and then retransformed following the methods suggested by Manning and Mullahy [2001] to produce estimated expenditures. As the OAF is a nonlinear estimator, bootstrap methods adapted for stratified sample design are utilized to calculate confidence intervals (see the STATA module *svybs* written by Stanislav Kolenikov available on the Boston College Statistical Software Components Archive).

The advantage of our econometric approach is that it directly estimates the OAF rather than inferring it by comparing differences in utilization rates and then multiplying by the average expenditure per visit (for an example of the utilization approach, see Sturm's [2002] estimates of the cost of adult obesity). Another advantage is that it makes no *a priori* judgments as to which medical conditions are attributable to obesity. Including all medical expenditures, not just those associated with specific diseases or conditions, is appropriate because overweight children may have higher treatment costs for conditions not caused by overweight.

Because the MEPS includes the codes from the *International Classification of Diseases, Ninth Revision* (ICD-9), it is possible to identify expenditures by disease code. We also report an analysis of the frequency of the primary disease code listed for each medical event in MEPS to see whether there are differences in the types of diagnoses reported for overweight and non-overweight children.

***Controls.*** The model of medical expenditure includes controls for characteristics other than obesity that may cause expenditures to differ. In our baseline model, Model 1, these include age, mother's age, gender, region, and residence in an urban area. Squared values of age and mother's age are also included. In Model 2, controls for race, income, and underweight are added. The race categories include indicators for Asian, American Indian, Hispanic, and African American. The family income categories are based on sufficiency of family income relative to the poverty level. The categories are: less than 100 percent of the poverty line, between 100 percent and 125 percent, between 125 percent and 200 percent (low income), 200 percent to 400 percent (middle income), and greater than 400 percent (high income). We omit category 1 in the regressions. A control for underweight (BMI below the fifth percentile) is also included. Thus, the model measures the effects of being overweight relative to similar children who are neither overweight nor underweight after controlling for other confounding factors.

These controls are similar to those used in the adult literature [Sturm, 2002] except that we include controls for underweight and do not include controls for smoking and problem drinking. Smoking and problem drinking were not measured for children in MEPS, so controls for this could not be included. Parental substance abuse may also affect children's health. For example, substance abuse during pregnancy is associated with low birth weight and later developmental problems [Joyce, Racine, and Mocan, 1992; Day et al., 2002]. Although we do not directly control for substance abuse by parents, the variable for underweight may be capturing some of its effects.

We also estimate a full model, our preferred model (Model 3), that includes additional controls for insurance status and disability. For children less than 5, limited activity is defined as being limited in any activity, while for children 5 and older, limited activity refers to being limited in non-school activities. The insurance variables are public coverage, private coverage, or uninsured, with uninsured being the omitted variable in the regressions. Children in MEPS who had dual coverage were classified as having private insurance.

## RESULTS

In our sample, see Table 1, the average age is around 11 years old, 51 percent are male, and 30 percent are black or Hispanic. Most children have some insurance: 17 percent have public insurance, 73 percent have private insurance, but 10 percent have no insurance. In 1998, the average medical expenditure was $493.38 across all children. About 71 percent had some medical expenditure. In Table 1, the sample means for overweight and non-overweight children are also shown. Overweight children are younger, more likely to be male, African American or Hispanic, and reside in the south. Overweight children are more likely to be in the lowest income category and less likely to be in the highest. In addition, they have younger and less educated mothers who are also less likely to be married. They are also more likely to be insured through a public program rather than through private insurance but about equally likely to be uninsured. About 3 percent of children have limited activity, and there is no significant difference by weight.

Table 2 shows the full distribution of our sample in comparison to the CDC growth chart percentiles. As expected, the current distribution of weight is shifted to the right relative to the static benchmark provided in the CDC growth chart. Overall, 35.2 percent of children are in the 85th percentile or above for their age and gender and would be considered overweight or at risk for overweight (see Table 1). Just over 20 percent of our sample is in the 95th percentile and classified as overweight. Our sample also has slightly more underweight children with over 7 percent in the 5th percentile of the growth chart.

**TABLE 2**
**BMI Distribution in Comparison to CDC Growth Chart Percentiles**

| CDC Growth Chart Percentiles | Cumulative Percent |
|---|---|
| 3 | 6.13 |
| 5 | 7.27 |
| 10 | 10.64 |
| 25 | 19.36 |
| 50 | 33.84 |
| 75 | 53.49 |
| 85 | 64.70 |
| 90 | 70.73 |
| 95 | 79.58 |
| 97 | 84.43 |

In Table 3, we report ICD-9 frequency for three categories of expenditures: acute care facilities expenditures, office-based expenditures, and prescription drug expenditures. Acute care facilities expenditures include emergency room expenditures and in-patient and outpatient visits to short-stay and children's hospitals. In MEPS, survey respondents reported the reason for each event, and MEPS assigned up to three

ICD-9 codes for each event. ICD-9 codes were grouped into 17 broad categories following the ICD-9 Clinical Modification that has been developed to classify the detailed morbidity data into useful groupings for the analysis of health statistics. In general there appears to be very little difference in the distribution of diagnoses for overweight and non-overweight children. For acute care facilities, injuries and poisonings account for the largest share (31 percent for overweight children, 39 percent for non-overweight children). For office-based visits and prescription drugs, the most common reason for an event was diseases of the respiratory system. Overall, there does appear to be a higher percentage of events due to diseases of the central nervous system among the obese (21 vs. 10 percent for acute care facilities, 17 vs. 10 percent for office-based visits, and 15 vs. 10 for prescription drugs). Diseases of the respiratory system also appear to be more frequent for the obese while there is a slightly higher incidence of injuries and poisonings among the non-obese. This difference could be explained by differences in activity levels, but caution is needed in interpreting these results. The relationship between obesity, respiratory disease and activity is not well understood and causation may go in multiple directions [Rodriguez et al., 2002]. In addition, this analysis does not include controls for differences in the obese and non-obese population that might impact use of medical care, such as type of insurance, family income, age, and gender.

**TABLE 3**

**Most Frequent Disease Classification for Overweight and Non-Overweight**

| Overweight | | Non-Overweight | |
|---|---|---|---|
| **Acute Care Facilities Expenditures** | | | |
| 31% | Injuries and Poisonings | 39% | Injuries and Poisonings |
| 21% | Diseases of the Central Nervous System | 10% | Diseases of the Respiratory System |
| 19% | Diseases of the Respiratory System | 8% | Diseases of the Central Nervous System |
| 6% | Symptoms, Signs and Ill-defined | 7% | Diseases of the Genitourinary System |
| 5% | Infectious and Parasitic Diseases | 6% | Mental Disorders |
| **Office Based Expenditures** | | | |
| 23% | Diseases of the Respiratory System | 21% | Diseases of the Respiratory System |
| 17% | Diseases of the Central Nervous System | 17% | Mental Disorders |
| 15% | Mental Disorders | 13% | Injuries and Poisonings |
| 9% | Infectious and Parasitic Diseases | 10% | Diseases of the Central Nervous System |
| 8% | Injuries and Poisonings | 9% | Infectious and Parasitic Diseases |
| **Prescription Drugs Expenditures** | | | |
| 44% | Diseases of the Respiratory System | 32% | Diseases of the Respiratory System |
| 15% | Diseases of the Central Nervous System | 20% | Mental Disorders |
| 11% | Mental Disorders | 10% | Diseases of the Central Nervous System |
| 8% | Symptoms, Signs and Ill-defined | 10% | Diseases of the Skin |
| 7% | Infectious and Parasitic Diseases | 7% | Infectious and Parasitic Diseases |

**TABLE 4a**
**Estimates of the Two-Part Health Expenditures Model (Overweight)**

| | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| | Probit | Logged Expenditures | Probit | Logged Expenditures | Probit | Logged Expenditures |
| Overweight | 0.001 | -0.084 | 0.038 | -0.055 | 0.044 | -0.024 |
| | (0.013) | (0.072) | (0.013) | (0.074) | (0.013) | (0.075) |
| Age | -0.071 | -0.117 | -0.061 | -0.103 | -0.058 | -0.082 |
| | (0.008) | (0.045) | (0.007) | (0.044) | (0.008) | (0.043) |
| Age Squared | 0.003 | 0.006 | 0.002 | 0.005 | 0.002 | 0.005 |
| | (0.0004) | (0.002) | (0.0004) | (0.002) | (0.0004) | (0.002) |
| Mother's Age | 0.041 | -0.014 | 0.026 | -0.038 | 0.027 | -0.052 |
| | (0.006) | (0.045) | (0.006) | (0.045) | (0.006) | (0.044) |
| Mother Age Squared | -0.0004 | 0.000 | -0.0003 | 0.001 | -0.0003 | 0.001 |
| | (0.0001) | (0.001) | (0.0001) | (0.001) | (0.0001) | (0.001) |
| Male | -0.005 | 0.133 | -0.026 | 0.126 | -0.027 | 0.130 |
| | (0.009) | (0.070) | (0.009) | (0.069) | (0.010) | (0.071) |
| Lives in MSA | -0.040 | -0.048 | -0.074 | -0.028 | -0.033 | -0.066 |
| | (0.010) | (0.072) | (0.067) | (0.074) | (0.012) | (0.071) |
| South | -0.083 | -0.061 | -0.045 | -0.021 | -0.035 | 0.012 |
| | (0.012) | (0.099) | (0.015) | (0.102) | (0.016) | (0.098) |
| West | -0.083 | -0.051 | -0.040 | -0.006 | -0.042 | -0.001 |
| | (0.023) | (0.109) | (0.018) | (0.118) | (0.016) | (0.114) |
| Northeast | -0.005 | -0.037 | 0.013 | -0.009 | 0.014 | 0.014 |
| | (0.018) | (0.099) | (0.019) | (0.102) | (0.020) | (0.098) |
| Black | | | -0.160 | -0.355 | -0.171 | -0.346 |
| | | | (0.031) | (0.095) | (0.032) | (0.095) |
| Asian | | | -0.243 | -0.294 | -0.234 | -0.210 |
| | | | (0.048) | (0.207) | (0.050) | (0.200) |
| American Indian | | | -0.111 | -0.283 | -0.149 | -0.239 |
| | | | (0.186) | (0.229) | (0.205) | (0.217) |
| Hispanic | | | -0.130 | -0.201 | -0.085 | -0.087 |
| | | | (0.014) | (0.076) | (0.016) | (0.075) |
| Income Category 2 | | | -0.016 | -0.087 | -0.010 | -0.181 |
| | | | (0.037) | (0.179) | (0.028) | (0.167) |
| Income Category 3 | | | -0.099 | 0.039 | -0.010 | -0.000 |
| | | | (0.034) | (0.123) | (0.019) | (0.137) |
| Income Category 4 | | | 0.018 | 0.108 | 0.061 | 0.006 |
| | | | (0.050) | (0.098) | (0.015) | (0.133) |
| Income Category 5 | | | 0.018 | 0.134 | 0.079 | -0.007 |
| | | | (0.085) | (0.113) | (0.016) | (0.145) |
| Underweight | | | 0.040 | -0.174 | 0.046 | -0.169 |
| | | | (0.029) | (0.109) | (0.027) | (0.109) |
| Limited Activity | | | | | 0.169 | 1.209 |
| | | | | | (0.067) | (0.189) |
| Mother's Education | | | | | 0.014 | 0.037 |
| | | | | | (0.003) | (0.015) |
| Public Insurance | | | | | 0.154 | 0.433 |
| | | | | | (0.019) | (0.128) |
| Private Insurance | | | | | 0.113 | 0.529 |
| | | | | | (0.023) | (0.116) |
| Constant | -0.491 | 5.736 | 0.223 | 6.182 | -0.877 | 5.435 |
| | (0.594) | (0.792) | (0.553) | (0.800) | (0.614) | (0.812) |
| $R^2$ | 0.0293 | 0.0148 | 0.0665 | 0.0880 | 0.0837 | 0.0641 |
| n | 4431 | 3077 | 4431 | 3077 | 4431 | 3077 |

Standard errors are in parentheses. Psuedo $R^2$ are reported for Probits

**TABLE 4b**
**Estimates of the Two-Part Health Expenditures Model (At Risk for Overweight)**

| | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| | Probit | Logged Expenditures | Probit | Logged Expenditures | Probit | Logged Expenditures |
| At-Risk | 0.020 | -0.073 | 0.050 | -0.064 | 0.053 | -0.051 |
| | (0.012) | (0.066) | (0.011) | (0.071) | (0.011) | (0.070) |
| Age | -0.71 | -0.115 | -0.061 | -0.102 | -0.060 | -0.083 |
| | (0.008) | (0.044) | (0.007) | (0.044) | (0.008) | (0.043) |
| Age Squared | 0.003 | 0.006 | 0.002 | 0.005 | 0.002 | 0.005 |
| | (0.0004) | (0.002) | (0.0003) | (0.002) | (0.0004) | (0.002) |
| Mother's Age | 0.040 | -0.013 | 0.026 | -0.038 | 0.027 | -0.052 |
| | (0.006) | (0.045) | (0.006) | (0.045) | (0.006) | (0.044) |
| Mother Age Squared | -0.0004 | 0.000 | -0.0003 | 0.001 | -0.0003 | 0.001 |
| | (0.00007) | (0.001) | (0.00007 | (0.001) | (0.00007 | (0.001) |
| Male | -0.026 | 0.134 | -0.028 | 0.127 | -0.028 | 0.132 |
| | (0.009) | (0.071) | (0.055) | (0.070) | (0.010) | (0.071) |
| Lives in MSA | -0.040 | -0.049 | -0.022 | -0.029 | -0.031 | -0.066 |
| | (0.010) | (0.073) | (0.011) | (0.074) | (0.012) | (0.071) |
| South | -0.083 | -0.060 | -0.045 | -0.020 | -0.134 | 0.014 |
| | (0.012) | (0.100) | (0.015) | (0.102) | (0.016) | (0.099) |
| West | -0.083 | -0.049 | -0.040 | -0.005 | -0.042 | -0.001 |
| | (0.024) | (0.110) | (0.018) | (0.118) | (0.017) | (0.115) |
| Northeast | -0.005 | -0.038 | 0.014 | -0.010 | 0.016 | 0.015 |
| | (0.018) | (0.099) | (0.019) | (0.102) | (0.020) | (0.098) |
| Black | | | -0.162 | -0.353 | -0.174 | -0.342 |
| | | | (0.030) | (0.096) | (0.030) | (0.096) |
| Asian | | | -0.242 | -0.299 | -0.233 | -0.214 |
| | | | (0.050) | (0.208) | (0.051) | (0.200) |
| American Indian | | | -0.108 | -0.288 | -0.146 | -0.246 |
| | | | (0.186) | (0.230) | (0.205) | (0.217) |
| Hispanic | | | -0.134 | -0.196 | -0.090 | -0.083 |
| | | | (0.014) | (0.077) | (0.017) | (0.075) |
| Income Category 2 | | | -0.015 | -0.090 | -0.010 | -0.183 |
| | | | (0.036) | (0.179) | (0.028) | (0.166) |
| Income Category 3 | | | -0.034 | 0.038 | -0.011 | 0.000 |
| | | | (0.018) | (0.123) | (0.019) | (0.138) |
| Income Category 4 | | | 0.048 | 0.108 | 0.058 | 0.007 |
| | | | (0.018) | (0.098) | (0.015) | (0.134) |
| Income Category 5 | | | 0.085 | 0.134 | 0.078 | -0.007 |
| | | | (0.019) | (0.112) | (0.015) | (0.145) |
| Underweight | | | 0.051 | -0.051 | 0.056 | -0.185 |
| | | | (0.026) | (0.026) | (0.024) | (0.111) |
| Limited Activity | | | | | 0.168 | 1.210 |
| | | | | | (0.017) | (0.188) |
| Mother's Education | | | | | 0.014 | 0.037 |
| | | | | | (0.003) | (0.015) |
| Public Insurance | | | | | 0.153 | 0.436 |
| | | | | | (0.019) | (0.129) |
| Private Insurance | | | | | 0.113 | 0.530 |
| | | | | | (0.023) | (0.116) |
| Constant | -0.532 | 5.718 | 0.210 | 6.182 | -0.880 | 5.449 |
| | (0.592) | (0.795) | (0.551) | (0.802) | (0.607) | (0.815) |
| $R^2$ | 0.030 | 0.015 | 0.068 | 0.028 | 0.085 | 0.064 |
| n | 4431 | 3077 | 4431 | 3077 | 4431 | 3077 |

Standard errors are in parentheses. Psuedo $R^2$ are reported for Probits.

Because ICD-9 codes in MEPS are coded from survey respondents' reported reasons for each medical event, our results cannot be directly compared to Wang and Dietz's [2002] analysis of the frequencies and trends in hospital discharges due to obesity related diagnoses. The diagnoses in their data were coded at the National Center for Health Statistics based on abstracts of the patient's chart. Because individuals reporting reasons for their expenditures do not have the same experience, expertise, or motivation to report comorbidities as the physicians who are filling out the patients' chart, the data are not directly comparable. In addition, MEPS only allows three ICD-9 codes while the hospital discharge data used in Wang and Dietz allows up to seven. Another difference with their study is that they restrict attention to a small subset of obesity-related diagnoses (diabetes, obesity, sleep apnea, and gallbladder disease) and consider only the in-hospital expenditures.

In Table 4, estimates of the two-part health expenditure model are presented. The first two columns in Table 4a show the results for Model 1 when overweight is the variable of interest. The first column reports the marginal effects from the Probit for having an expenditure while the second column reports the estimated coefficients for the (logged) expenditures model. Results for Models 2 and 3 are given in the third through sixth column. Table 4b shows the estimates for the same models when "at-risk" (BMI above $85^{th}$ percentile) is the variable of interest. In the baseline model, overweight is not a significant predictor of having a medical expenditure, but as more controls are added to the model, the economic and statistical significance of the coefficient on overweight (or at risk for overweight) increases. Underweight children are also more likely to have medical expenditures, but the effect is not significant in either regression. Other factors that significantly affect the likelihood of a medical expenditure include mother's education and age, insurance, race, and activity limitations. Children who have limited activity, older or more educated mothers, access to insurance, or higher income are more likely to have some health expenditures. Non-white children are less likely to incur a medical expenditure (significant for all race categories but American Indian). The results for at-risk of overweight are similar.

As is often found in the health economics literature [Newhouse et al., 1989], the regressions on medical expenditures explain only a small portion ($R^2 = 0.064$ in our preferred model, Model 3) of the variation. Limited activity, insurance status, mother's education all significantly increase expenditures, while African Americans experience significantly lower expenditures. Neither obesity nor underweight are significant predictors of the level of medical expenditures in any specification.

Based on the two-part model, we calculated the overweight attributable fraction (OAF) of medical expenditures for children. These estimates are provided in Table 5. Consistent with our results above, the economic significance of childhood obesity is greater when we use the predictions from the full model (Model 3). We find that the OAF for our preferred model is 0.5 percent. To apply the OAF, we multiply it by the total medical expenditures for children in 1998 calculated by obtaining the weighted sum of expenditures reported in MEPS ($24.83 billion). Obesity accounts for $124 million (0.005 * $24.83 billion = $124 million) in 1998. Somewhat surprisingly the OAF calculated for those with BMI above the $85^{th}$ percentile ("at risk") is smaller than the OAF for BMI above the $95^{th}$ percentile. While one possible explanation for this is that having a BMI between the 85th and 95th percentile reduces average medical expenditures, a more likely explanation is that the OAFs are not estimated with precision.

**TABLE 5**
**Obesity Attributable Fraction**

| | Model 1 | | Model 2 | | Model 3 | |
|---|---|---|---|---|---|---|
| | **Overweight** | **At Risk** | **Overweight** | **At Risk** | **Overweight** | **At Risk** |
| Average Difference in the Probability of Medical Expenditure | 0.0002 | 0.007 | 0.007 | 0.017 | 0.009 | 0.018 |
| Average Difference in Expenditure | -3.355 | -5.149 | -2.143 | -4.433 | -0.922 | -3.650 |
| Overweight Attributable Fraction | -0.016 | -0.014 | -0.001 | 0.001 | 0.005 | 0.004 |
| Confidence Interval | | | | | | |
| Upper Bound | -0.047 | -0.600 | -0.032 | -0.048 | -0.023 | -0.044 |
| Lower Bound | 0.015 | 0.031 | 0.033 | 0.048 | 0.036 | 0.049 |

Although our methods are different, the aggregate impact on total medical expenditures we find is about the same as that found by Wang and Dietz [2002]. Wang and Dietz only look at inpatient expenditures for some obesity associated diseases and only measure obesity when it is listed as a diagnosis. They estimate that obesity raised inpatient expenditures from $35 million annually in 1979-1981 to $127 million annually in 1997-1999 (in 2001 dollars). This apparent growth in expenditures may be misleading because it is estimated using the frequency of diagnoses codes recorded by the hospital. Changes in hospital re-imbursement by Medicare as well as private insurers has resulted in significant changes in hospital caseloads and the incentives to "upcode" diagnoses.

Our estimates must be also interpreted with caution. First, our results indicate that being overweight has an effect on the probability of obtaining medical care but not on the level of expenditure conditional on the expenditure being positive. Second, although the coefficient on overweight is significantly different from zero at the 95 percent level in our preferred specification of the probit, it is not significant in specifications with fewer controls. We also estimated utilization models (not reported here) of the three categories of medical visits (acute facility visits, office based visits, and prescriptions) using a Poisson model and found that the coefficient on overweight (or overweight and at-risk) was not significantly different from zero in any specification. A limitation of our methods is that there may be unobserved differences between overweight and non-overweight children, such as chronic health conditions, that are associated with health expenditures but not captured in the model. If this is the case, reducing the prevalence of obesity might lead to even smaller costs savings than estimated here. Further research on the relationship between weight and other health conditions will be important next step in understanding the impact of this epidemic.

A final consideration in interpreting our results is the degree of confidence in our estimate. Although it is common to report a point estimate of excess expenditures without reporting a confidence interval [e.g., Sturm, 2002; Wang and Dietz, 2002], it is important to consider whether such estimates have statistical as well as economic significance. Because our estimates are based on a two-part model of medical expenditures, we cannot easily obtain analytic expressions for the confidence interval estimates. Instead, we use the bootstrap method [Effron and Tibshirani, 1993]. Because the MEPS sample is a stratified sample in which some strata were oversampled, we used a bootstrapping algorithm that mimics the original sampling techniques. For each bootstrap iteration, the algorithm drew the same number of observations within each primary sampling unit as were present in the original sample. We find that the confidence intervals on the estimated OAFs for medical expenditures are wide (for the obesity attributable fraction, the 95 percent confidence intervals are -0.023 to 0.036; for the at-risk attributable fraction, the 95 percent confidence intervals are –0.044 to 0.049), include zero, and even include some negative estimates that imply that excess weight leads to lower expenditures. Notice that this occurs despite our finding that overweight significantly raises the probability of a medical expenditure and has no significant effect on the level of expenditures. This suggests that great care should be used when drawing inferences from estimated medical expenditures in the absence of evidence of statistical significance.

In conclusion we find that children that are at risk or overweight are more likely than their non-overweight peers to have medical expenditures but there is no significant difference in predicted expenditures for those that obtain some form of care. Socio-economic and demographic differences between overweight and non-overweight children may mask these differences in expenditures. We find no significant effects of obesity when these controls are not included. An analysis of the frequency of diagnoses for obese and non-obese children also reveals few differences. Finally, although excess weight in children is estimated to raise U.S. medical expenditures by $124 million, the confidence intervals on these estimates are wide and we cannot reject a nil effect.

## DISCUSSION

Some obesity is surely attributable to genetic differences and is unlikely to be affected by policy changes. But the recent, rapid increase in pediatric obesity cannot be attributed to genetics. Many causes have been considered, including the effects of changes in TV viewing, exercise, and family eating habits [Dennison, Erb, and Jenkins, 2002]. Economists have begun to consider the role of changes in the price of food and the value of time as well as the effect of reductions in physical education in school [Philipson, 2001; Chou et al., 2004]. Although it is difficult to isolate how much obesity is due to genetics and how much is due to socio-demographic factors, we can ask by how much would children's medical expenditures fall if we returned to the level of pediatric obesity experienced two and three decades ago (corresponding to the percentiles in the CDC growth charts). We find that 20 percent of children are overweight (BMI above the $95^{th}$ percentile) in 1998 and they have annual excess medical expenditures of $124 million. If we reduced the percent overweight from 20 percent back to 5 percent, this could save an estimated $93 million annually.

Although we estimate that the excess medical expenditures attributable to overweight and at risk for overweight may be large in aggregate, there are several reasons to believe that this may be a hidden problem from the perspective of parents and policymakers. First, there is little difference in the frequencies of diagnoses of obese and non-obese children. Although the clinical literature does show differences in morbidity by obesity, these differences are not apparent when diagnoses data are aggregated into broader categories. Second, when controls for socio-economic and demographic differences are not included, there is no difference in the probability or level of medical expenditure for overweight and non-overweight children. Moreover, although we find a significant difference in the probability of a medical expenditure, we find no difference in the level of spending conditional on having expenditures. At the level of the individual child, the differences in predicted medical expenditures are small. Expenditures for overweight children are on average $12.09 higher per year (OAF = 0.5 percent).[1] Furthermore, the resulting confidence intervals on our estimate of excess medical expenditure are wide and do not exclude a nil or even small negative impact.

Perhaps most importantly, we have only considered the short-run, economic impact of childhood obesity. Although few studies have examined the long-term effects of pediatric overweight using longitudinal data, most studies that have been done find that the risks of adult mortality and morbidity are increased [Dietz, 1998 a/b; Must and Strauss, 1999; Bao et al., 1997; Gunnell et al., 1998]. Furthermore, overweight children are more likely to become overweight adults and the health consequences and economic burden of adult obesity is estimated to be large [Sturm, 2002]. Our analysis also does not include the short and long run impacts of non-economic costs such as substance abuse problems and depression. Because the long-term consequences of overweight will not be apparent until adulthood and because health care costs and diagnoses do not appear to be significantly different for overweight and non-overweight children, the potentially severe long-term consequences may be overlooked while the children are still young and a change can be effected.

## NOTES

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1. Total medical expenditures would be $124 million lower if the overweight children were no longer overweight. Hence average medical expenditures would have been $24833 – $124 lower. Dividing by the number of children represented in the survey gives average expenditures of $490.92 per non-overweight child. Approximately 20 percent of children are overweight, so we can calculate how high their expenditures would have to be to yield the average medical expenditure for the survey $493.388. This implies that overweight children must spend approximately $503.01 on average or $12.09 more than an non-overweight child.

## REFERENCES

**Albala, C., Yanez, M., Devoto, E., Sostin, C., Zeballos, L. and Santos, J.** Obesity as a Protective Factor for Postmenopausal Osteoporosis. *International Journal of Obesity and Related Metabolic Disorders*, November 1996, 1027-32.

**Barlow, S. E. and Dietz, W. H.** Obesity Evaluation and Treatment: Expert Committee Recommendations. *Pediatrics*, September 1998, 1-11.

**Bao, W., Srinivasan, S. R., Valdez, R., Greenlund, K. J., Wattingney, W. A., and Berenson, G. S.** Longitudinal Changes in Cardiovascular Risk from Childhood to Young Adulthood in Offspring of Parents with Coronary Artery Disease: the Bogalusa Heart Study. *Journal of the American Medical Association*, December 1997, 1749-54.

**Bray, G. A.** Complications of Obesity. *Annals of Internal Medicine*, December 1985, 1052-62.

**Cawley, J.** The Impact of Obesity on Wages. *Journal of Human Resources*, Spring 2004, 451-474.

**Chou, S., Grossman, M., and Saffer, H.** An Economic Analysis of Adult Obesity: Results from the Behavioral Risk Factor Surveillance System. *Journal of Health Economics*, May 2004, 565-87.

**Cole, T. J.** Weight-Stature Indices to Measure Underweight, Overweight, and Obesity, in *Anthropometric Assessment of Nutritional Status*, edited by J.H. Himes. New York: Wiley-Liss, 1991, 83-111.

**Coller, M., Harrison, G. W., and McInnes, M. M.** Evaluating the Tobacco Settlement: Are the Damages Awards Too Much or Not Enough? *American Journal of Public Health*, June 2002, 984-989.

**Cypcar, D. and Lemanski, R. F.** Asthma and Exercise. *Clinics in Chest Medicine*, June 1994, 351-68.

**Day, N. L., Leech, L. S., Richardson, G. A., Cornelius, M. D., Robles, N. and Larkby, C.** Prenatal Alcohol Exposure Predicts Continued Deficits in Offspring Size at 14 Years of Age. *Alcoholism: Clinical and Experimental Research*, October 2002, 1584-91.

**Dennison, B. A., Erb, T. A., and Jenkins, P. L.** Television Viewing and Television in Bedroom Associated with Overweight Risk Among Low-Income Preschool Children. *Pediatrics*, June 2002, 1028-35.

**Dietz, W. H. and Bellizzi, M. C.** Introduction: the Use of Body Mass Index to Assess Obesity in Children. *American Journal of Clinical Nutrition*, July 1999, 123S-5S.

**Dietz, W. H.** Childhood Weight Affects Adult Morbidity and Mortality. *Journal of Nutrition*, February 1998a, 411S-414S.

____________. Health Consequences Of Obesity in Youth: Childhood Predictors of Adult Disease. *Pediatrics*, March 1998b, 518-25.

**Effron, B. and Tibshirani, R. J.** *An Introduction to the Bootstrap*. New York: Chapman and Hall, 1993.

**Figueroa-Colon, R., Franklin, F. A., Lee, J. Y., Aldridge, R., and Alexander, L.** Prevalence of Obesity with Increased Blood Pressure in Elementary School-Aged Children. *Southern Medical Journal*, August 1997, 806-13.

**Frankenfield, D. S., Rowe, W.A., Cooney, R. N., Smith, J. S., and Becker, D.** Limits of Body Mass Index to Detect Obesity and Predict Body Composition. *Nutrition*, January 2001, 26-30.

**Freedman, D. S., Dietz, W. H., Srinivasan, S. R., and Berenson, G. S.** The Relation of Overweight to Cardiovascular Risk Factors Among Children and Adolescents: The Bogalusa Heart Study. *Pediatrics*, June 1999, 1175-82.

**Gunnell, D. J., Frankel, S. J., Nanchanhal, K., Peters, T. J., and Smith, G. D.** Childhood Obesity and Adult Cardiovascular Mortality: A 57-Y Follow-Up Study Based on The Boyd Orr Cohort. *American Journal of Clinical Nutrition*, June 1998, 1111-8.

**Guo, S. S., Wu, W., Chumlea, W. C., and Roche, A. F.** Predicting Overweight and Obesity in Adulthood from Body Mass Index Values in Childhood and Adolescence. *American Journal of Clinical Nutrition*, September 2002, 653-8.

**Joyce, T., Racine, A. D., and Mocan, N**. The Consequences and Costs of Maternal Substance Abuse in New York City: A Pooled, Time-Series, Cross Sectional Analysis. *Journal of Health Economics*, October 1992, 297-314.

**Kuczmarski, R. L. and Flegal, K. M.** Criteria for Definition of Overweight in Transition: Background and Recommendations for the United States. *American Journal of Clinical Nutrition*, November 2000, 1074-81.

**Lazarus, R., Bauer, L., Webb, K., and Blyth, F.** Body Mass Index in Screening for Adiposity in Children and Adolescents: Systemic Evaluation Using Receiver Operating Characteristic Curves. *The American Journal of Clinical Nutrition*, April 1996, 500-6.

**Leung, A. K. C. and Robson, W. L. M.** Childhood Obesity. *Postgraduate Medicine*, August 1990, 123-3.

**Manning, W. G. and Mullahy, J.** Estimating Log Models: To Transform or Not to Transform? *The Journal of Health Economics*, July 2001, 461-94.

**Miller, L. S., Zhang, X., Novotny, T., and Rice, D. P.** State Estimates of Medicaid Expenditures Attributable to Cigarette Smoking, Fiscal Year 1993. *Public Health Reports*, March/April 1998a, 140-51.

**Miller, L. S., Zhang, X., Rice, D. P., and Max, W.** State Estimates of Total Medical Expenditures Attributable to Cigarette Smoking, 1993. *Public Health Reports*, September/October 1998b, 447-58.

**Morrison, J. A., Barton, B. A., Biro, F. M., Daniels, S. R., and Sprecher, D. L.** Overweight, Fat Patterning, and Cardiovascular Disease Risk Factors in Black and White Boys. *Journal of Pediatrics*, October 1999a, 451-7.

**Morrison, J. A., Sprecher, D. L., Barton, B. A., Waclawiw, M. A., and Daniels, S. R.** Overweight, Fat Patterning, and Cardiovascular Disease Risk Factors in Black and White Girls. The National Heart, Lung, and Blood Institute Growth and Health Study. *Journal of Pediatrics*, October 1999b, 458-464.

**Must, A. and Strauss, R. S.** Risks and Consequences of Childhood and Adolescent Obesity. *International Journal of Obesity Related Metabolic Disorders*, March 1999, 1523-9.

**National Center for Health Statistics.** Health United States, 2002 With Chartbook on Trends in the Health of Americans. Hyattsville, Maryland: National Center for Health Statistics,1998.

**Newhouse, J. P., Manning, W. G., Keeler, E. B., and Sloss, E. M.** Adjusting Capitation Rates Using Objective Health Measures and Prior Utilization. *Health Care Financing Review*, Spring 1989, 47-54.

**Olson, E.** U.N. Warns That Many Children, Rich and Poor, Are Obese. *New York Times*, May 17, 2002.

**Palta, M., Prineas, R. J., Berman, R., and Hannan, P.** Comparison of Self-Reported and Measured Height and Weight. *American Journal of Epidemiology*, February 1982, 223-30.

**Philipson, T.** The World Wide Growth in Obesity: An Economic Research Agenda. *Health Economics*, January 2001, 1-7.

**Pinhas-Hamiel, O., Dolan, L. M., Daniels, S. R., Standiford, D., Khoury, P. R., and Zeitler, P.** Increased Incidence of Non-Insulin Dependent Diabetes Mellitus Among Adolescents. *Journal of Pediatrics*, May 1996, 608-15.

**Rodriguez, M. A., Winkleby, M. A., Ahn, D., Sundquist, H., and Kraemer, H. C.** Identification of Population Subgroups of Children and Adolescents with High Asthma Prevalence. *Archives of Pediatric Adolescent Medicine*, March 2002, 269-75.

**Schweizer, P., Lenz, M. P., and Kirschner, H. J.** Pathogenesis and Symptomatology of Cholelithiasis in Childhood: A Prospective Study. *Digestive Surgery*, 2000, 459-67.

**Spencer, E. A., Spencer, E. A., Appleby, P. N., Davey, G. K., and Key, T. J.** Validity of Self-Reported Height and Weight in 4808 EPIC-Oxford Participants. *Public Health Nutrition*, June 2002, 561-5.

**Strauss, R. S.** Comparison of Measured and Self-Reported Weight and Height in a Cross-Sectional Sample of Young Adolescents. *International Journal of Obesity Related Metababolic Disorders*, August 1999, 904-8.

**Strauss, R. S. and Pollack, H. A.** Epidemic Increase in Childhood Overweight, 1986-1998. *Journal of the American Medical Association*, December 2001, 2845-8.

**Sturm, R.** The Effects of Obesity, Smoking and Drinking on Medical Problems and Costs. *Health Affairs*, March/April 2002, 245-253.

**Vanhala, M. J., Vanhala, P. T., Keinanen-Kuikaanniemi, S. M., Kumpusalo, E. A., and Takala, J. K.** Relative Weight Gain and Obesity as a Child Predict Metabolic Syndrome as an Adult. *International Journal of Obesity Related Metabolic Disorders*, June 1999, 656-9.

**Wang, G. and Dietz, W. H.** Economic Burden of Obesity in Youths Aged 6-17 Years: 1979-1999. *Pediatrics*, May 2002, 1- 6.

**Warner, K. E., Hodgson, T. A., and Carroll, C. E.** Medical costs of Smoking in the United States: Estimates, Their Validity, and Their Implications. *Tobacco Control*, Autumn 1999, 290-300.

**Whitaker, R. C., Wright, J. A., Pepe, M. S., Seidel, K. D., and Dietz, W. H.** Predicting obesity in young adulthood from childhood and parental obesity. *New England Journal of Medicine*, September 1997, 869-73.