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ABSTRACT

Since the late 1970s, the number of obese adults in the United States has grown by over 50 percent. This paper examines the factors that may be responsible for this rapidly increasing prevalence rate. To study the determinants of adult obesity and related outcomes, we employ micro-level data from the 1984-1999 Behavioral Risk Factor Surveillance System. These repeated cross sections are augmented with state level measures pertaining to the per capita number of fast- food restaurants, the per capita number of full-service restaurants, the price of a meal in each type of restaurant, the price of food consumed at home, the price of cigarettes, clean indoor air laws, and hours of work per week and hourly wage rates by age, gender, race, years of formal schooling completed, and marital status. Our main results are that these variables have the expected effects on obesity and explain a substantial amount of its trend. These findings control for individual-level measures of household income, years of formal schooling completed, and marital status.

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I. Introduction

Since the late 1970s, the number of obese adults in the United States has grown by over 50 percent. This paper examines the factors that may be responsible for this rapidly increasing prevalence rate. We focus on societal forces which may alter the cost of nutritional and leisure time choices made by individuals and specifically consider the effect of changes in relative prices, which are beyond the individual's control, on these choices. The principal hypothesis to be tested is that an increase in the prevalence of obesity is the result of several economic changes that have altered the lifestyle choices of Americans. One important economic change is the increase in the value of time, particularly of women, which is reflected by the growth in their labor force participation rates and in their hours of work. The reduction in home time, due in part to the slow growth in income among certain groups, has been associated with an increase in the demand for convenience food. Another important change is the rise in the real cost of cigarette smoking due to increases in the money price of cigarettes, the diffusion of information concerning the harmful effects of smoking, and the enactment of state statutes that restrict smoking in public places and in the workplace. This relative price change may have reduced smoking, which tends to increase weight. A final set of relative price changes revolves around the increasing availability of fast food, which reduces search and travel time and changes in the relative costs of meals consumed in fast-food restaurants, full-service restaurants, and meals prepared at home.

To study the determinants of adult obesity and related outcomes, we employ micro-level data from the 1984-1999 Behavioral Risk Factor Surveillance System. These repeated cross sections are augmented with state level measures pertaining to the per capita number of restaurants, the prices of a meal in fast-food and full-service restaurants, the price of food consumed at home, the price of cigarettes, clean indoor air laws, and hours of work per week and hourly wage rates by age, gender, race, years of formal schooling completed, and marital status. Our main results are that these variables have the expected effects on obesity and explain a substantial amount of its trend. These findings control for individual-level measures of age, race, household income, years of formal schooling completed, and marital status.

II. Background

The significance of research on obesity and sedentary lifestyle is highlighted by the level of mortality and health problems and by the costs associated with these behaviors. According to McGinnis and Foege (1993) and Allison et al. (1999), obesity and sedentary lifestyles result in over 300,000 premature deaths per year in the United States. By comparison, the mortality associated with tobacco, alcohol and illicit drugs is about 400,000, 100,000, and 20,000 deaths per year, respectively. Stevens et al. (1998) estimate that excess body weight increases the risk of death for individuals between 30 and 74 years old. These deaths result from coronary artery disease, stroke, high blood pressure, cancers of the colon, breast, and prostate, and diabetes. This makes obesity and sedentary lifestyle second only to tobacco in causing premature death.

The monetary costs of obesity and sedentary lifestyle include the cost of caring for those who are ill with related diseases and lost productivity from related illness and mortality. Wolf and Colditz (1998) estimate that in 1995 the costs of obesity were $99.2 billion, which was 5.7 percent of the total costs of illness. Public financing of these costs is considerable since approximately half of all health care is paid by the federal government and state and local governments, and the prevalence of obesity continues to increase.

The National Institute of Diabetes and Digestive Kidney Diseases (1996) reports that Americans spend $33 billion dollars annually on weight reduction products and services. There are often serious health risks associated with some of these products that can affect a large number of consumers and increase the cost of obesity. Kolata (1997) reports that physicians wrote 18 million prescriptions for fenfluramine and dexfenfluramine in 1996 (often used with phentermine, as part of the combination known as fen-phen) prior to the removal of the two top diet drugs from the market at the request of the Food and Drug Administration. It was found that these drugs may cause heart valve damage in as many as 30 percent of patients.

The significance of research on obesity and sedentary lifestyle is also highlighted by the level and growth of obesity rates. Until recently, obesity in the U.S. was a fairly rare occurrence. Obesity is measured by the body mass index (BMI), also termed Quetelet's index, and defined as weight in kilograms divided by height in meters squared (kg/m^2). According to the World Health Organization (1997) and the National Heart, Lung, and Blood Institute (1998), a BMI value of between 20 and 22 is "ideal" for adults regardless of gender in the sense that mortality and morbidity risks are minimized in this range. For a woman whose height is five feet five inches, this corresponds to a weight between 120 and 130 pounds. For a six-foot-tall man, the corresponding weight is between 150 and 165 pounds. Persons with BMI equal to or greater than 30 are classified as obese. Hence a five-foot-five-inch-tall woman is obese at 190 pounds. A six-foot tall-man is obese at 235 pounds.

Trends in the mean body mass index of adults ages 18 years of age and older and the percentage who are obese between 1959 and 1994 are presented in Table 1. These data come from heights and weights obtained from physical examinations conducted in the first

National Health Examination Survey (NHES I) between 1959 and 1962, the first National Health and Nutrition Examination Survey (NHANES I) between 1971 and 1975, the second National Health and Nutrition Examination Survey (NHANES II) between 1976 and 1980, and the third National Health and Nutrition Examination Survey (NHANES III) between 1988 and 1994.[1] Note the extremely modest upward trends in the two outcomes in Table 1 until the period between 1978 (the mid-year of NHANES II) and 1991 (the mid-year of NHANES III). In that thirteen-year period, the number of obese Americans grew by 55 percent. At the same time, BMI rose by 1.24 kg/m^2 or by 5 percent, which represents a six-pound weight gain for the woman and man described above. The corresponding figures between 1960/61 (the mid-year of NHES I) and 1978 were a 10 percent increase in the number of obese persons, and a 1 percent increase in BMI.

The trends in Table 1 are important because the stability of BMI in the two decades between NHES I and NHANES II is masked in longer-term trends in this variable between 1864 and 1991 presented by Costa and Steckel (1997).[2] They include NHES I and NHANES III in their time series but do not include NHANES I and NHANES II. Philipson and Posner (1999), Philipson (2001), and Lakdawalla and Philipson (2002) use Costa and Steckel's time series as the point of departure of a penetrating analysis in which increases in BMI over time are caused by reductions in the strenuousness of work. Lakdawalla and Philipson (2002) show that BMI is negatively related to an index of job strenuousness in repeated cross sections from the National Health Interview Survey for the period 1976 through 1994 and in the National Longitudinal Survey of Youth for the period from 1982 through 1998. This important finding confirms their explanation of the long-term trend in

BMI. Yet it sheds little light on the trend between NHANES II and NHANES III because the job strenuousness measure was very stable in the periods that they consider.

The trends in Table 1 also are important because public health objectives presented in Healthy People 2010: National Health Promotion and Disease Prevention Objectives (Public Health Service 2001) target an obesity prevalence rate of 15 percent for adults in 2010. The available data suggest that in 2010 the prevalence of obesity in the U.S. is likely to be more than twice the target or approximately 33 percent.[3] Since the available data indicate that the prevalence of obesity continues to increase each year, it is likely that the mortality and disease costs of obesity will be significantly higher in 2010 than they are today. Although the prevalence of obesity continues to rise, the reasons for this increase remain unknown and speculative. The development of policies to reverse this trend requires an understanding of the underlying behavioral processes. We direct our attention to this aim in the remainder of the paper. We begin and conclude this section by examining briefly insights provided by aggregate time series data and by three empirical studies by economists (Cawley 1999; Ruhm 2000; Lakdawalla and Philipson 2002).

The shift from an agricultural or industrial society to a post-industrial society emphasized by Philipson (2001) in his economic analysis of obesity has been accompanied by innovations that economize on time previously allocated to the nonmarket or household sector. One such innovation has economized on time spent in food preparation at home and is reflected by the introduction of convenience food for consumption at home and by the growth of fast-food and full-service restaurants. The growth in restaurants, particularly fast food restaurants, has been dramatic. According to the Census of Retail Trade, the per capita number of fast-food restaurants doubled between 1972 and 1997, while the per capita number of full-service restaurants rose by 35 percent (Bureau of the Census 1976, 2000).

Fast food and convenience food are inexpensive and have a high caloric density (defined as calories per pound) to make them palatable (Schlosser 2001). Total calories consumed rises with caloric density if the reduction in the total amount of food consumed does not fully offset the increase in density. Mela and Rogers (1998) report that this occurs in many cases. Indeed, available per capita calories increased from 3,250 calories per day in 1970 to 3,800 calories per day in 1997 (Bureau of the Census various years).[4] Also, the annual per capita consumption of corn sweeteners has risen from 38.2 pounds in 1980 to 86.8 pounds in 1998. This has been somewhat offset by a reduction in the use of sugar. Per capita annual consumption of total sweeteners increased from 123.0 pounds per year in 1980 to 155.1 pounds per year in 1998. To exacerbate these factors, there is evidence that caloric consumption is habituating, where habituation is defined as a positive effect of past consumption on current consumption (Naik and Moore 1996; Cawley 1999).

The increasing prevalence of convenience food and fast food is part of the long-term trend away from the labor-intensive preparation of food at home prior to consumption. But it also can be attributed in part to labor market developments since 1970 that have witnessed declines in real income of certain groups and increases in hours of work and labor force participation rates by most groups. Real income of single earner households decreased from 1970 to 1993 and was only one percent higher in 1998 than in 1970 (Bureau of the Census various years). Real income of single men and women followed a similar downward pattern. At the same time, the labor force participation of married women jumped from 41 percent in 1970 to 62 percent in 1998. As a result, real income of all married-couple families rose by 31 percent between those two years. According to Bluestone and Rose (1997), between 1970 and 1990, the typical two earner family increased market work by 600 hours a year. This is about one and a half days a week on the job.

These data show that more household time is going to market work. There is correspondingly less time and energy available for home and leisure activities such as food preparation and active leisure. The increases in hours worked and labor force participation rates, reductions in wage rates, and declines or modest increases in real income experienced by certain groups appear to have stimulated the demand for inexpensive convenience and fast food which has increased caloric intakes. At the same time, the reduction in the time available for active leisure has reduced calories expended.

The final trend that we wish to call attention to is the anti-smoking campaign, which began to accelerate in the early 1970s. Individuals who quit smoking typically gain weight. The real price of cigarettes rose by 164 percent between 1980 and 2001 (Orzechowski and Walker 2002). This large increase resulted in part from four Federal excise tax hikes, a number of state tax hikes and the settlement of the state lawsuits filed against cigarette makers to recover Medicaid funds spent treating diseases related to smoking. The period since the late 1970s also has been characterized by a dramatic increase in the percentage of the population residing in states that have enacted clean indoor air laws that restrict smoking in public places and in the workplace. For example, in 1980, 6 percent of the population resided in states that restrict smoking in the workplace. By 1999, this figure stood at 42 percent (Centers for Disease Control and Prevention website http://www2.cdc.gov/nccdph/osh/state).

Very recent contributions to the determinants of obesity by economists have focused on the roles of unemployment, job strenuousness, and prices of food prepared at home. Ruhm

(2000) finds that body mass index and obesity are inversely related to state unemployment rates in repeated cross sections from the Behavioral Risk Factor Surveillance System for the years 1987-1995. His interpretation of these results is that the value of time is negatively related to the unemployment rate. Cawley (1999) reports that BMI is negatively related to the real price of groceries in the National Longitudinal Survey of Youth (NLSY) for the period from 1981 through 1996. His price variable is the price of food at home as reported by the Bureau of Labor Statistics. It incorporates variations over time and among the four major geographic regions of the U.S. Cawley is careful to note that more expensive food does not always contain more calories than cheaper food and that consumers can substitute towards inexpensive, caloric food when this overall price index rises.

Using the same NLSY panel employed by Cawley, Lakdawalla and Philipson (2002) also find a negative effect of a price of food at home measure that varies by city and year on BMI. They control for unmeasured time effects but do not control for unmeasured area effects. Moreover, their methodology assumes that each individual faces an upward sloping average or marginal cost function of food. This differs from the standard assumption that consumers are price takers. We extend the research just summarized by considering many more potential determinants of BMI and obesity, especially those with significant trends. This is important in attempting to explain the growth in obesity since the late 1970s. Although job strenuousness, unemployment, and grocery prices are important determinants of BMI and obesity, trends in the first two variables cannot account for the increase in obesity. Moreover, a focus on the role of food at home prices ignores the dramatic shift away from the consumption of meals at home during the past thirty years.

III. Analytical Framework

This section outlines aspects of a simple behavioral model of the determinants of obesity using standard economic tools. Cawley (1999) and Philipson and his colleagues (Philipson and Posner 1999; Lakdawalla and Philipson 2002) have developed more refined models, although the Philipson studies focus on body mass index rather than on obesity. Our aim is to provide an elementary framework to consider the effects of variables not explicitly treated in the models just cited.

We begin with a relationship in which obesity is a function of an individual's energy balance over a number of time periods or ages. Let B_j, the energy balance in period j, be defined as

$$B_j \equiv C_j - E_j, \tag{1}$$

where C_j are calories consumed in period j and E_j are calories expended in all activities in period j. Obesity (O) is a cumulative function of the individual's energy balance over a number of periods:

$$O = O(\sum_j B_j, \varepsilon), \tag{2}$$

where ε is a vector of variables that is specific to an individual and is related to his or her genetic predisposition towards obesity. Age, gender, race, and ethnicity also may enter this vector because they influence the process by which energy balances are translated into changes in body mass. Equation (2) highlights that a model of obesity must explain the determinants of calories consumed and calories expended.

No one desires to be obese, although some people gain more utility from food than others. Therefore, it is useful to consider obesity as the byproduct of other goals. Becker's (1965) household production function model of consumer behavior provides a framework for studying the demand for caloric intakes and expenditures because it recognizes that consumers use goods and services purchased in the market together with their own time to achieve or produce more fundamental commodities that enter their utility or preference functions. Three such commodities are health, the positive senses of taste and smell associated with the consumption of food, and the entertainment provided by dining with family and friends in restaurants or at home. In turn, they are related to the calories, nutrients, and other ingredients contained in food and to the setting in which it is consumed. The relationship between health and caloric consumption is complex. Persons who are too heavy or too thin face elevated risks of mortality and illness. Thus persons at recommended weight levels can maintain health by setting caloric intake equal to calories expended. With calories expended held constant, an increase in calories consumed increases the health of those who are too thin and lowers the health of those who are too heavy.

Households consume the ingredients in food via meals, and meals are produced with inputs of food and time. Time enters the production of meals in a variety of ways. Obviously, it is required to consume the food, but it also is required to obtain and prepare it. The production of meals at home is the most intensive in the household's own time, while the production of meals in restaurants is the least intensive in that time. For a given quality, food consumed in restaurants is more expensive than prepared food consumed at home, which in turn is more expensive than food prepared and consumed at home.

Since time is a scarce resource, households have incentives to substitute towards less time-intensive methods of producing meals when the value or price of time rises. One model of the labor market assumes that employees are offered an hourly wage rate and are free to work as many hours as they want at that wage. In this model, the price of an hour allocated to food preparation equals the market wage rate. An increase in the wage creates obvious incentives to purchase more convenience foods and to increase consumption of food in fast-food restaurants.

An alternative model of the labor market (for example, Trejo 1991) assumes that hours of work are a job characteristic over which both firms and workers have preferences. Firms that demand more hours per worker must pay a higher hourly wage rate. This approach can be expanded to include a flexible hours sector of the economy and a number of constrained hours sectors (Abowd and Ashenfelter 1981). In the constrained hours model, an exogenous increase in work hours makes home time a scarcer resource and raises its price. This creates the same incentives to purchase more convenience and restaurant food that are generated by an increase in the wage rate in the unconstrained model.

The other variable in the energy balance equation is caloric expenditure. Calories are expended at work, doing home chores, and at active leisure. Calories expended at work depend on the nature of the occupation as emphasized by Lakdawalla and Philipson (2002). Individuals who work more hours in the market will substitute market goods for their own time in other activities. An increase in hours of work raises the price of active leisure and generates a substitution effect that causes the number of hours spent in this activity to fall. An increase in hours of work also lowers the time allocated to household chores.

Based on these considerations, we translate equation (2) from a theoretical to an empirical construct by writing it as

$$O = O(C, L, HC, EW, CS, A, G, R), \tag{3}$$

where C is calories consumed, L is active leisure (either the time allocated to this activity or the total energy expended by an average person in performing each of a variety of leisure activities), HC is a similar concept pertaining to household chores, EW is energy expended by an average person in the occupation performed by the individual at issue, CS is cigarette smoking, A is age, G is gender, and R summarizes racial and ethnic background. Cigarette smoking is included in equation (3) because smokers have higher metabolic rates than non-smokers. They also consume fewer calories than non-smokers, so that cigarette consumption is a partial indicator of caloric intakes in previous periods.

The framework that we have discussed generates demand functions for calories consumed, active leisure, household chores, and cigarette smoking (another object of choice in the utility function) that depend on a set of exogenous variables specified below and consisting mainly of prices and income. Substitution of these equations into equation (3) yields:

$$O = O(H, F, P, S, M, EW, A, G, R), \tag{4}$$

where H is hours of work; F is family income; P is a vector of prices including the prices of convenience foods, the prices of meals consumed at fast-food and at full-service restaurants, the prices of food requiring significant preparation time, and the price of cigarettes; S is years of formal schooling completed; and M is marital status.[5] We term equation (4) a reduced-form equation because we treat the variables on the right-hand side as exogenous. Our goal is to estimate it and a corresponding equation for body mass index.

We have not discussed the roles of a number of variables in the reduced form. With hours of work held constant, an increase in income expands real resources. If health is a superior commodity (a commodity whose optimal value rises as income rises with prices held constant) and if an individual weighs less than his or her recommended weight, the demand for calories grows. Even for consumers at or above recommended weight, calorie consumption increases if foods that are important contributors to the positive senses of taste and smell are rich in calories. In addition, visits to "upscale" full-service restaurants are likely to rise with income since the entertainment provided by dining with friends and family in these settings is likely to have a positive income elasticity. Their impact on obesity depends on the caloric content of the food consumed.

The above factors do not necessarily mean that body mass or obesity will rise with income because the increase in active leisure may offset or more than offset the increase in caloric intakes. In addition, the price of time rises with income since the household experiences an increase in the ratio of market goods to its own time. This makes home time a relatively scarcer resource and generates the type of substitution effects towards convenience and fast food that accompany an increase in hours of work. Note that the income or real resource effects that accompany these two increases in the price of time go in opposite directions. This is because an increase in money income (F) raises real resources, while an increase in hours of work (H) lowers real resources.

Reductions in convenience food prices, fast-food restaurant prices, and certain full-service restaurant prices, or increases in the prices of foods requiring significant preparation time raise calorie consumption by inducing a substitution towards higher caloric intakes. It is conceivable that the demand for active leisure may rise, although we consider this offset to the potential increase in obesity to be unlikely. The price vector is not limited to food prices because cigarette smoking is associated with lower weight levels, as previously noted. Many studies summarized by Grossman (2001) have shown that cigarette consumption falls as the money price of cigarettes rises. Restrictions on smoking in public places and in the workplace raise the "full price" of smoking by increasing the inconvenience costs associated with this behavior. Trends in the enactment of clean indoor air laws also may reflect increased information about the harmful effects of smoking.

Years of formal schooling completed may increase efficiency in the production of a variety of household commodities, expand knowledge concerning what constitutes a healthy diet, and make the consumer more future oriented. These forces should lower the incidence of obesity, possibly by lowering the demand for dense food or by increasing the demand for active leisure by more than demand for calories. Marital status may affect the time available for household chores and active leisure in a variety of ways.

Consumption of meals in restaurants requires travel and in some cases waiting time. Hence, the full price of a meal in a restaurant should reflect this component as well as the money price. Travel and waiting time should fall as the per capita number of restaurants in the consumer's area of residence rises. Therefore, we include the per capita numbers of fast-food and full-service restaurants in our empirical analysis. This is particularly important because we do not have direct measures of wage rates or hours of work, although we do use proxies in some specifications. Restaurants, particularly fast food restaurants, should locate in areas in which consumers have relatively high time values. Consequently, the availability of these restaurants in a particular area is a negative correlate of travel and waiting time and a positive correlate of the value that consumer's place on their time.

IV. <u>Empirical Implementation</u>

To investigate the determinants of body mass index and obesity, we employ repeated cross sections from the Behavioral Risk Factor Surveillance System (BRFSS) for the years 1984 through 1999. The BRFSS consists of annual telephone surveys of persons ages 18 and older conducted by state health departments in collaboration with the Centers for Disease Control and Prevention (CDC). Fifteen states participated in the first survey in 1984. The number of participating states grew to 33 in 1987, to 45 in 1990, and to all 51 states (including the District of Columbia) in 1996. The average number of interviews per state ranged from approximately 800 in 1984 to 1,800 in 1990, and to 3,000 in 1999. These state stratified cluster samples are used by CDC to make state-specific estimates of the prevalence of lifestyle indicators and behavioral factors that contribute to positive or negative health outcomes.

Definitions, means, and standard deviations of all variables employed in the regressions in Section V are contained in Table 2. Except where noted, they are based on the sample of 1,111,074 that emerges when observations with missing values are deleted. The means and standard deviations in the table and those cited in the text are computed based on BRFSS sampling weights and are representative of the population at large. The weights are not employed in the regression estimates since DuMouchel and Duncan (1983) and Maddala (1983, pp. 171-173) have shown that this is not required in the case of exogenous stratification.

Self-reported data on height and weight allow us to construct the body mass index of each respondent and indicators of whether he or she is obese. It is well known that self-reported anthropometric variables contain measurement error with heavier persons more likely to underreport their weight. Therefore, we employ procedures developed by Cawley (1999) to correct for these errors. The third National Health and Nutrition Examination Survey (NHANES III) contains both actual weight and height from physical examinations and self-reported weight and height. For persons 18 years of age and older in NHANES III, we regress actual weight on reported weight and the square of reported weight. We also regress actual height on reported height and the square of reported height. These regressions are estimated separately for eight groups: white male non-Hispanics, white female non-Hispanics, black male non-Hispanics, black female non-Hispanics, Hispanic males, Hispanic females, other males, and other females.[6] The coefficients from these regressions are combined with the self-reported BRFSS data to adjust height and weight and to compute BMI and the obesity indicator.[7] These two measures are employed as alternative dependent variables. Given the large sample size, we fit linear probability models rather than logit or probit models when obese is the outcome.

The corrected mean values of BMI and obese all exceed values computed from reported weight and height. For BMI, the corrected figure is 26.04 kg/m^2, and the uncorrected figure is 25.40 kg/m^2. According to the corrected data, 17.54 percent of the population is obese, compared to an uncorrected figure of 13.75 percent. The simple correlation coefficient between corrected and uncorrected BMI exceeds 0.99. The simple correlation coefficients between the corrected and uncorrected obesity indicator is smaller (0.86) but still very substantial.

The trends in corrected BMI and the corrected percentages of the population obese are plotted in Figure 1. Between 1984 and 1999, BMI increased by 2.13 kg/m^2 or by 9 percent, and the number of obese adults more than doubled. While the algorithm for adjusting self-reported weight and height does raise BMI and obesity, the adjusted levels are still lower than those in NHANES III. Nevertheless, annual rates of change in BRFSS appear to be comparable to those between NHANES II and III.

The roles of all the independent variables in Table 2 in body mass and obesity outcomes were discussed in Section III. Therefore, in the remainder of this section, we discuss the definitions and sources of the variables that are appended to the BRFSS based on state of residence and survey year.[8] In addition, we address several estimation issues.

The number of fast-food restaurants and the number of full-service restaurants are taken from the <u>1982, 1987, 1992, and 1997 Census of Retail Trade</u> (Bureau of the Census 1986, 1989, 1994, 2000). For other years, these variables are obtained from interpolations and extrapolations of state-specific logarithmic time trends. Except for 1999, the Bureau of the Census classifies establishments based on the Standard Industrial Classification (SIC) system. Fast-food restaurants correspond to refreshment places (SIC category 5812/40). These are establishments primarily selling limited lines of refreshments and prepared food items. Included are establishments which prepare pizza, barbecued chicken, and hamburgers for consumption either on or near the premises or for "take-home" consumption. Full-service restaurants are restaurants and lunchrooms (SIC category 5812/10). They are establishments engaged in serving prepared food selected by the patron from a full menu. Waiter or waitress service is provided, and the establishment has seating facilities for at least 15 patrons. The distinction between fast-food and full-service restaurants made by the Bureau of the Census is not clear-cut. In particular, many full-service restaurants serve the type of high-caloric and inexpensive food that is offered by fast-food restaurants. In preliminary regressions, the coefficients of the two types of restaurants were very similar. Therefore, we summed the fast-food and full-service restaurants and employ the per capita number in the regressions in Section V.

The full-service restaurant price pertains to the average cost of a meal in this type of restaurant and was taken from the same source as the number of full-service restaurants. The Census of Retail Trade contains data on the number of restaurants whose average cost of a meal falls in specific categories by state. The categories are less than $2.00, $2.00-$4.99, $5.00-$6.99, $7.00-$9.99, $10.00-$14.99, $15.00-$19.99, $20.00-$29.99, and $30.00 and over. We assigned midpoints to the closed end categories, an average cost of $1.50 to the smallest category, and an average cost of $45.00 to the highest category. We then computed price as a weighted average of the average cost in each category, where the weights are the number of restaurants in each category in the state. The use of midpoints and the failure to adjust for quality imply that the restaurant price variable suffers from measurement error. In addition, the price in 1982, which is required to obtain estimates for 1984, 1985, and 1986, is based on much broader average cost categories than those in 1987.[9]

The fast-food price and the food at home price come from prices in the ACCRA Cost of Living Index, published quarterly by the American Chamber of Commerce Researchers Association (ACCRA various years), for between 250 and 300 cities. Three fast-food prices are reported by this source: a McDonald's Quarter-Pounder with cheese, a thin crusted cheese pizza at Pizza Hut or Pizza Inn, and fried chicken at Kentucky Fried Chicken or Church's. We obtained quarterly state-specific prices as population-weighted averages of the city prices and then averaged over the four quarters in a given year to get annual prices.

The ACCRA collects prices of 59 different items and also reports the weight of each item in the typical budget a of household whose head holds a midmanagement position. The budget shares of each of the three fast-food items were equal to each other in the period from 1984 through 1999. Therefore, the fast-food price employed in the regressions is a simple average of the three ACCRA fast-food prices divided by the annual Bureau of Labor Statistics Consumer Price Index (CPI) for the U.S. as a whole (1982-84 = 1). All other money prices, money income, and wage rates in the regressions are deflated by the CPI.[10]

The food at home price is constructed from 13 food prices obtained by ACCRA. As in the case of fast-food prices, we obtained quarterly state-specific prices as population-weighted averages of the city prices and then averaged over the four quarters in a given year to get annual prices. The final food at home price is a weighted average of these thirteen prices, where the weights are the average expenditure shares of these items as reported by the ACCRA during the years from 1984 through 1999. Since the weights are fixed over time, the resulting price is a Laspeyres food at home price level.[11]

The price of cigarettes is taken from the Tax Burden on Tobacco (Orzechowski and Walker 2002 and formerly published by the Tobacco Institute). The price in this source is given as a weighted-average price per pack, using national weights for each type of cigarette (regular, king, 100-mm) and type of transaction (carton, single pack, machine). It is inclusive of Federal and state excise taxes.[12] The clean indoor air regulations (private, government, restaurant, and other) are taken from the Centers for Disease Control and Prevention website (http://www2.cdc.gov/nccdph/osh/state).

The BRFSS contains extremely limited information on labor market variables. Therefore, we use the Current Population Survey (CPS) Merged Outgoing Rotation Groups Files (Bureau of Labor Statistics and Bureau of the Census 2000) to obtain usual hours worked per week by employed workers, hourly wage rates of employed workers (usual weekly earnings divided by usual hours worked), and employment rates (ratios of employment to population) by state and year for 64 demographic groups. These groups are defined by gender (males and females), race (white non-Hispanic and other), marital status (married and other), age (25 through 44 and 45 through 64), and years of formal schooling completed (less than 12, 12, 13-15, and 16 and over). Since many persons between the ages of 18 and 24 are attending college and many persons over the age of 64 are retired, we limit the regressions containing labor market variables to persons between the ages of 25 and 64. Since earnings and hours are poorly measured for the self-employed, we also exclude this group from the CPS tabulations and from the BRFSS regressions that include the CPS variables.

We construct two alternative measures of the value of time. One is usual hours worked per week and per worker in one of the 64 cells in a given state and year multiplied by the employment ratio in that cell (the number of employed people divided by the sum of the number of employed people, the number of unemployed people, and the number of people not in the labor force). The second is the hourly wage rate of persons in the cell multiplied by the employment rate. The first variable can be interpreted as expected hours worked per week (hours worked per week multiplied by the probability of working those hours), and the second variable can be interpreted as the expected hourly wage rate. The expected hours variable is the most relevant one if one thinks that workers cannot freely vary their hours, while the expected wage variable is a better measure of the value of time when workers can vary their hours. Both variables, however, reflect changes in labor force and employment rates, which are particularly relevant in the case of women, as well as changes in hours or wage rates among employed workers. Each BRFSS respondent between the ages of 25 and 64 is assigned an expected hours of work and an expected wage based on the respondent's state of residence, year of interview, and demographic characteristics.

The main aim of the empirical analysis in the next section is to see how much of the trend in the prevalence of the percentage of the population that is obese and in body mass index can be accounted for by the state-specific variables just defined. If pure trend terms are included in the regressions, this aim is difficult to achieve because of multicollinearity between the state-specific variables and time. This problem is exacerbated because the restaurant measure had to be interpolated and extrapolated for years not covered by the Census or Retail Trade. Therefore, we fit three models for each of the two outcomes. The first includes only variables measured in the BRFSS, time, and the square of time. The second omits the trend terms and includes the state-specific variables, while the third includes all regressors. We then use the second and third models to “explain” trends in obesity and BMI between 1984 and 1999 and in between 1960/61 (the mid-year of NHES I) and 1978 (the mid-year of NHANES II). We use a quadratic trend rather than time dummies in order to address the behavior of obesity prior to 1984. Moreover, a specification with time dummies forces the national mean of the dependent variable to lie on the regression line in each year. Thus it “stacks the deck” in favor of the pure trend model relative to the model with state-specific variables. To be consistent with our treatment of trend effects, we employ a quadratic specification for each continuous variable. In preliminary regressions we found evidence that most of these variables had non-linear effects. We go part of the way towards a full fixed-effects specification by including a set of dichotomous variables for each state except one in all regressions. Hence we control for unmeasured determinants of obesity that vary among states but do not vary over time. These unmeasured determinants may be correlated with the state-specific variables. We allow the coefficients of the state-specific variables to be determined by within-state variation over time and by national variation over time in one of the two specifications with these variables. We emphasize results with this specification because it does a much better job of explaining trends in obesity before 1984 than the specification with trend terms.

V. Results

Table 3 and 4 contain ordinary least squares regressions of body mass index and the probability of being obese, respectively, for persons 18 years of age and older. Three regressions are presented in each table. Robust or Huber (1967) standard errors, which allow for state/year clustering, are obtained.

The six regressions in the two tables have low explanatory power, with R squares ranging from 4 to 8 percent. In part this is because more than a million people are included in the regressions. But the main reason is that body mass index and obesity have large genetic components. In this context it is important to emphasize that our aim is to explain the increasing prevalence of obesity rather than to explain why a given individual is obese. This perspective is important because genetic characteristics of the population change slowly, while the incidence of obesity has increased rapidly. To be sure, some individual characteristics, such as years of formal schooling completed, may be correlated with genetic determinants of weight outcomes.[13] But there is little reason to believe that the state-specific variables that we consider are correlated with heredity.

Focusing on the effects of the individual characteristics in the first model in each table, one sees that age has an inverted U-shaped effect. BMI peaks at an age of approximately 57, while the probability of being obese peaks at an age of 45. Black non-Hispanics and Hispanics have higher values of both outcomes than whites, while persons of other races have lower values. Males have higher BMI levels than females, but females are more likely to be obese. Married and widowed persons have higher levels of BMI than single (never married) and divorced individuals, these relations carry over to the prevalence of obesity.

Years of formal schooling completed and real household income have negative effects on BMI and the probability of being obese. There is little evidence that the schooling effect falls as the amount of schooling rises. Differentials between college graduates and those who attended college but did not graduate are almost as large as differentials between the latter group and persons who did not attend high school. Graduation from college appears to maximize the probability that BMI is in the range that minimizes mortality and morbidity risks since the differentials between those with some college and those who are high school graduates are small.

Although the negative effect of household income on BMI or obesity falls as income rises, the effect remains negative throughout almost all the observed income range. At weighted sample means, the income elasticity of body mass index is modest **(**0.03**)**. The income elasticity of the probability of being obese of 0.50 is more substantial.

Finally both time and the square of time have positive and statistically significant coefficients. This suggests that the two outcomes increased at an increasing rate during the period from 1984 through 1999.

The second model in each table introduces the set of state-specific regressors. Despite the relatively large number of variables in the set and the considerable amount of intercorrelations among them, most of their coefficients have the expected signs and are statistically significant. Regardless of the outcome considered, the per capita number of restaurants and the real price of cigarettes have positive and significant effects at weighted sample mean. Along the same lines, the real fast-food restaurant price, the real food at home price and the real full- service restaurant price have negative and significant effects at weighted sample means.

The effects of the clean indoor air laws do not show a consistent pattern. Restrictions on cigarette smoking in restaurants have no role in weight outcomes. This is surprising because these restrictions are most likely to encourage a substitution of food for cigarettes. Restrictions in state and local government workplaces are associated with higher levels of BMI and higher prevalence rates of obesity, but the coefficients are not significant. Private workplace restrictions never are significant and are associated with higher levels of BMI and obesity. Restrictions in elevators, public transportation, and theaters (reflected by the dichotomous indicator other) raise both two weight outcomes, with the obesity effect achieving significance.

Table 5 contains elasticities of the two outcomes with respect to the continuous state-specific variables at the points of weighted sample means. As in the case of income, the elasticity of body mass index with respect to any of these variables is modest. The largest elasticity of 0.17 pertains to the per capita number of restaurants. This elasticity is seven times larger than the absolute value of the income elasticity. When the probability of being obese is the outcome, the elasticities in Table 5 are much more substantial. For example, a 10 percent increase in the number of restaurants increases the number of obese people by 9 percent. With regard to the three direct food price variables, the greatest responses occur when the real fast-food restaurant price varies. The elasticities of BMI and the probability of being obese with respect to this price are –0.05 and –0.39, respectively. Like Cawley (1999) and Lakdawalla and Philipson (2002), we find that weight outcomes rise when food at home prices decline. The magnitude of the relevant elasticity is, however, only 70 to 90 percent as large as the corresponding fast-food restaurant price elasticity. The full-service restaurant price elasticity is never larger than -0.08, but this elasticity may be biased downward, as noted above.

The positive cigarette price elasticities in Table 5 indicate substitution between calories and nicotine. The magnitude of the effect is almost as large as the food at home price elasticity. These results point to an unintended consequence of the anti-smoking campaign. In particular, state and Federal excise tax hikes and the settlement of state Medicaid lawsuits have caused the real price of cigarettes to rise substantially. Our findings suggest that this development contributed to the upward trend in obesity.

The large elasticities with regard to the per capita number of restaurants emerge from models that hold the real fast-food restaurant price and the real full-service restaurant price constant. A simple supply and demand model predicts that these two variables should be negatively correlated if the demand function for restaurants is more stable than the supply function and positively correlated if the supply function is more stable. Only a minor change in the restaurant elasticity occurs when the price variables are deleted, implying that the supply function is very elastic. The reader should keep in mind that the per capita number of restaurants is employed as a proxy for the travel time and waiting time costs involved in obtaining meals at these eating places. A literal interpretation of the elasticities in Table 5 implicates fast-food and full-service restaurants as culprits in undesirable weight outcomes. But a very different interpretation emerges if one recognizes that the growth in these restaurants, and especially fast-food restaurants, is to a large extent a response to the increasing scarcity and increasing value of household or nonmarket time.

The third model in Tables 3 and 4 includes the trend terms as well as the state-specific variables. At the mean full-service restaurant price, the marginal effect of this variable switches from negative to positive. The marginal effects of the remaining continuous state-specific variables retain their signs but are reduced substantially in absolute value. In our view, these results suggest that the third model is plagued by multicollinearity and that it employs too many regressors to explain trends in obesity. We return to this issue at the end of this section.

Table 6 introduces our two alternative measures of the value of time into the second and third models in Tables 3 and 4. These two measures are the expected hourly wage (the state-year-age-race-gender-schooling-marital-status-specific hourly wage rate multiplied by the corresponding employment rate) and the expected number of hours worked per week. It is important to bear in mind that both variables reflect changes in labor force and employment rates, which are particularly relevant in the case of women, as well as changes in hours or wage rates among employed workers. We restrict the sample to persons between the ages of 25 and

64. The sample size is reduced from 1,111,074 to 722,090 when 18 to 24 year olds, those older than 64, and observations with missing CPS cells are deleted. We only report coefficients of the hourly wage, the hourly wage squared (columns 1 and 2), weekly hours and weekly hours squared (columns 3 and 4) in Table 6.

Either the expected wage rate or the expected number of hours of work has a positive and very significant effect on each of the two outcomes. At the point of means, the elasticity of BMI with respect to the wage is 0.03, and the elasticity of BMI with respect to hours is 0.04. When the probability of being obese is considered, these elasticities are 0.32 and 0.19, respectively. The significance and magnitudes of the wage and hours effects are not altered when the trend terms are included.

These findings concerning the relationship between obesity and labor market outcomes are related to but not entirely comparable with those in studies by Averett and Korenman (1996), Cawley (2000), and Lakdawalla and Philipson (2002). The first two studies stress causality from obesity to labor market outcomes, perhaps due to discrimination. Behrman and Rosenzweig (2001) report, however, that the negative effect of BMI on wage rates can be traced to unobserved individual effects. Lakdawalla and Philipson (2002) argue that the negative effect of earned income on BMI (beyond a certain income level) is weakened if work is sedentary. Our specification differs from those found in the research just discussed because we examine the effect of time allocated to the market or its value on obesity with household income held constant. Hence, we focus on pure substitution effects associated with a rise in the price of time. Our results can be traced to incentives to reduce active leisure and to increase the consumption of convenience food and fast food because these are ways to economize on scarce time.

The main purpose of this paper is to gain an understanding of the factors associated with the stability in obesity between the early 1960s and the late 1970s and the rapid increase since that time. Tables 7 and 8 address the latter issue by examining how well selected models predict the increases in obesity and related outcomes between 1984 and 1999. Table 7 pertains to persons ages 18 years of age and older, while Table 8 pertains to persons between the ages of 25 and 64. The estimates in Table 7 are based on regression models in Table 3. The procedure simply is to multiply the change in a given variable between the initial and terminal year by the coefficient of that variable. In the cases of race/ethnicity, schooling, marital status, the clean indoor air laws, and variables in quadratic form, predicted changes associated with related variables (married, divorced, and widowed in the case of marital status) are summed to form a single factor.

During the period at issue BMI rose from 24.94 kg/m^2 to 27.07 kg/m^2, and the percentage of the population obese rose from 11.05 percent to 24.04 percent. The model with the individual characteristics and the trend explains 97 percent of the growth in BMI and 99 percent of the growth in the number of obese persons. The model with the state-specific variables slightly overpredicts both outcomes. Hence, there is little to choose between these two models; either one does about as good a job in explaining the trend as the other. This finding highlights why problems arise when both the trend and the state-specific variables are included in the same regression. In particular, trends in the state-specific variables account for trends in obesity. Once these variables are included the trend becomes redundant.[14]

Regardless of the model employed, race/ethnicity, schooling, marital status, and household income contribute little to an understanding in the behavior of obesity over time. Indeed, the last three variables predict reductions in obesity. This is because schooling, real household income, and the fraction of the population divorced grew in the period at issue, while the fraction of the population married declined.

Without trend terms, the increase in the per capita number of restaurants makes the largest contribution to trends in weight outcomes, accounting for 69 percent of the growth in BMI and 68 percent of the rise in the percentage obese. The real price of cigarettes ranks second, with a contribution roughly one third as large as that due to restaurants**.** The three real food prices considered fell during the period at issue, causing the weight outcomes to rise. But the declines were modest and explain little of the trend. The largest contribution is made by the food at home price and contributes 6 percent to the trends in BMI and obesity**.** The rising prevalence of clean indoor air laws has about the same impact as the reduction in the fast-food restaurant price.

The model with all variables slightly overpredicts both weight outcomes. It attributes most of the increase in these outcomes to unmeasured trend factors. This is not surprising given the diminished effects of the state-specific variables in this specification. Despite the high correlation between the restaurant measure and time, the former still accounts for 10 percent of the growth in BMI and 12 percent of the rise in the percentage obese.

Table 8 contains a similar analysis of trends in weight outcomes for persons between the ages of 25 and 64. The four models employed in Table 6 are used for each outcome. Recall that trends in either labor market variable reflect the behavior of the employment rate over time as well as the behavior of hours worked per employed person or the wage rate per employed person.

The contributions of factors already discussed do not change when the age range of the sample is restricted. The new results pertain to the hourly wage and weekly hours. The contribution of either variable to trends in weight outcomes is rather modest. In the model without time and its square, the hourly wage ranks fourth in importance after trends in restaurants, cigarette prices and food at home price. It explains about 5 percent of the growth in a given outcome. In the model with time and its square, the trend terms, hourly wage ranks second among determinants other than the trend, although the magnitude of its contribution to trends in weight outcomes does not change. If pure time effects are excluded, weekly hours is the least important determinant of trends in BMI and the percentage obese. With the trend terms, weekly hours ranks higher than fast-food restaurant price, full-service restaurant price and clean indoor air laws as a determinant of the growth in the number of obese persons between the ages of 25 and 64. The absolute value of the negative household income effect in Table 8 is approximately the same in magnitude as wage or hours effect. Hence an explanation as to why the growth in household income did not result in better weight outcomes is that it was accompanied by increases in labor force participation, hours of work, and wage rates.

As shown in Table 1, BMI, and the percentage obese were very stable between 1960/61 (the mid-year of NHES I) and 1978 (the mid-year of NHANES II). We conclude by applying our estimated regression coefficients to trends in exogenous variables between those two years in an attempt to explain why weight outcomes did not rise in that eighteen-year period. The results of this exercise are contained in Table 9. Panel A of the table pertains to persons ages 18 and over, while panel B pertains to persons ages 25 through 64.

Since a consistent series on household income is not available over this period, median family income is used in its place. This variable as well as marital status and schooling are taken from the Bureau of the Census (various years). The initial year values of the number of fast-food and full-service restaurants are averages of the figures reported in the <u>1958 and 1963 Census of</u>

Business (Bureau of the Census 1961, 1966). Effects due to fast-food and full-service restaurant prices are omitted because there are no measures of these prices in 1960. Trends in the food at home price are based on the series in the Consumer Price Index (Bureau of the Census various years).[15] Labor market variables for the initial year come from the 1960 Census of Population (Bureau of the Census 1964). To avoid distorting the upward trend due to predicted troughs at negative time values, a linear approximation to the trend effect is employed.[16]

Focusing on panel A, one sees that the specification with the trend fails to explain the stability of weight outcomes between 1960 and 1978. That specification predicts much larger increases in these outcomes than the very modest ones that actually occurred. Increases in schooling and real family income and changes in marital status offset a very small portion of the pure trend component. The model that replaces the trend with state-specific variables is much more successful. It predicts very small reductions in the outcomes compared to the very small increases that actually took place. The estimates in panel B tell the same story. Taken as a whole, the results in the table underscore the problems that can arise when a trend is used to capture the effects of unobserved time-varying variables.

The main reason for the success of the model with state-specific variables is that the per capita number of full-service restaurants fell between 1960 and 1978. While more credence might be given to this result if the per capita number of fast-food restaurants declined, the distinction between these two types of restaurants is not "hard and fast." Some full-service restaurants serve the high-caloric food offered by fast-food restaurants. Hence the growth of both types of restaurants after 1978 but the growth in only one type before that year is the explanation that we offer for the stability in obesity between 1960 and 1978 and its expansion after 1978.

Our explanation is subject to several caveats. Trends in cigarette prices account for little of the trend in obesity because the real cigarette price in 1960 was almost the same as the real price in 1978. If, however, a year in the mid-1960s had been selected as the initial year, the real price of cigarettes would have fallen, and the predicted negative cigarette price component would have been larger in absolute value. More importantly, adult smoking participation rates fell between 1960 and 1978 as well as after that year. Absolute declines in the two periods were very similar (Public Health Service 1996). Obesity should have increased in both periods due to this factor alone. Our model appears to be missing a variable that can account for the reduction in smoking in the earlier period since the increasing prevalence of clean indoor air laws has small effects.[17] This suggests that it also is missing a variable that can offset the positive impact of declines in smoking on obesity.

VI. Summary

In this paper we have examined the extent to which relative price variations determine variations in body mass index and obesity among adults and the extent to which changes in relative prices over time contribute to an understanding of trends in weight outcomes. The set of relative prices includes state level measures pertaining to the per capita number of restaurants, the price of a meal in fast-food and full-service restaurants, the price of food consumed at home, the price of cigarettes, clean indoor air laws, and hours of work per week and hourly wage rates by age, gender, race, years of formal schooling completed, and marital status. Our main results are that these variables have the expected effects on obesity and explain a substantial amount of its trend. These findings control for individual level measures of household income, years of formal schooling completed, and marital status.

Two results stand out. The first is the large positive elasticities associated with the per capita number of restaurants and the importance of trends in this variable in explaining the stability of obesity between 1960 and 1978 and the increase since 1978. A literal interpretation of this result implicates fast-food and full-service restaurants as culprits in undesirable weight outcomes. But a very different interpretation emerges if one recognizes that the growth in these restaurants, and especially fast-food restaurants, is to a large extent a response to the increasing scarcity and increasing value of household or nonmarket time. Indeed, we have presented evidence of direct positive effects of increased labor market attachment on obesity. In a fuller model that perhaps treated restaurant availability as endogenous, labor market attachment would have indirect effects that operate through restaurant availability.

The second result that stands out is the positive cigarette price coefficient. This result points to an unintended consequence of the anti-smoking campaign. In particular, state and Federal excise tax hikes and the settlement of state Medicaid lawsuits have caused the real price of cigarettes to rise substantially. Our findings suggest that this development contributed to the upward trend in obesity.

In a sense, both findings underscore the price that must be paid to achieve goals that in general are favored by society. Expanded labor market opportunities for women have resulted in significant increases in families' command of real resources and higher living standards. Cigarette smoking is the largest cause of premature death, and declines in this behavior have obvious health benefits. Our results suggest that these two factors contribute to the rising prevalence of obesity. Whether public policies should be pursued that offset this ignored consequence of previous actions to discourage smoking and increase market opportunities depends on the costs and benefits of these policies.

The reduced form approach to the determinants of obesity in this paper would be complemented and enriched by a structural approach in which caloric intake, energy expenditure, and cigarette smoking are treated as endogenous determinants of weight. A study that takes this approach deserves high priority on an agenda for future research.

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Footnotes

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[1] The figures in Table 1 are based on our computations with these surveys. They differ slightly from published estimates because we consider a somewhat broader age range and because we include pregnant women. The exclusion of pregnant women and persons below the age of 20 has almost no impact on levels or trends.

[2] Costa and Steckel (1997) and Fogel and Costa (1997) show that the long-term increase in BMI is the major "proximate cause" of the long-term reduction in mortality and morbidity in the U.S. and other countries. This finding is analogous to the key role played by birthweight in infant survival outcomes. Of course, the studies just cited recognize that BMI is endogenous.

[3] This assumes that the increase in the percentage of the population who are obese of 0.59 percentage points a year between the mid-years of NHANES II and NHANES III will continue until 2010.

[4] Available calories are greater than calories actually consumed since some proportion are lost to waste and spoilage.

[5] In an unconstrained hours of work model, the hourly wage rate replaces hours of work in equation (4).

[6] The other category consists of persons who are not white, black, or Hispanic and primarily includes Asians, Pacific Islanders, Native Americans, and Eskimos. The number of people in this category is very small.

[7] We eliminated the extremely small number of BRFSS respondents with an uncorrected BMI of less than 11 or greater than 140.

[8] Starting in 1989, county of residence codes are contained in the BRFSS. These codes, however, are missing for many respondents.

[9] In that year, the categories are less than \$2.00, \$2.00-\$4.99, \$5.00-\$9.99, and \$10.00 and over.

[10] The ACCRA reports a cost of living index for each city which can be employed to compute a state-specific cost-of-living index. We chose not to do this because the index reflects cost differentials among areas for households whose heads hold midmanagement positions. Clearly, these households have higher incomes than those headed by clerical workers or by average urban consumers. In particular, homeownership costs are more heavily weighted than they would be if the index reflected clerical workers' or average urban consumers' standards of living.

[11] A detailed description of the food at home price is available on request.

[12] Starting in 1990, the source contains two price series: one that includes generic brands and one that excludes these brands. For purposes of comparability, the series that excludes generic brands is employed. The two price series are extremely highly correlated.

[13] Suppose that u and g are unobserved variables. An increase in u, which might represent mental ability, raises schooling; while an increase in g, which might represent the genetic propensity towards obesity, raises this outcome and BMI. If g and u are negatively correlated, the schooling coefficient in an obesity or bmi regression is biased away from zero in a negative direction. The reverse holds if u and g are positively correlated. Trends in schooling over periods as short as three or four decades are unlikely to be explained by trends in u. But some caution should be exercised when cross-sectional regression coefficients are applied to these trends. For a detailed analysis of the roles of heredity and the environment in schooling, body mass, and wage outcomes, see Behrman and Rosenzweig (2001).

[14] A purist might demand a result in which the trend is insignificant in a regression with the state-specific variables. But given the degree of collinearity in the data, this is an extremely demanding criterion.

[15] To preserve the magnitude of this variable, it is multiplied by the ratio of the ACCRA real food at home price to the CPI real food at home price in 1984.

[16] Let α be the coefficient of time (t) and let β be the coefficient of the square of time. The trend component in Table 16 is $(\alpha + 2\beta*8)*18$. The term in parentheses is the effect of time on a given outcome evaluated at its mean value of 8 in the BRFSS. This coincides with the coefficient of t that emerges when t^2 is omitted from the set of regressors. A literal interpretation of the quadratic specification suggests a trough in a year prior to 1984 (the first year of the

BRFSS) and given by $t = -\alpha/2\beta$. This is inconsistent with long-term trends in BMI reported by Costa and Steckel (1997). As an alternative, we also computed the trend component as $18\alpha + 18^2\beta$. The two estimates are very similar.

[17] Evans, Farrelly, and Montgomery (1999) find that workplace smoking bans have very large negative effects on smoking participation. Moore (2001) reports this relationship reflects the underlying preferences of workers and employers rather than a direct causal process.

Table 1

Trends in Body Mass Index and the Percentage Obese,
Persons 18 Years of Age and Older[a]

Survey	Period	Body Mass Index[b]	Percentage Obese[c]
NHES I[d]	1959-1962	24.91	12.73
NHANES I	1971-1975	25.14	13.85
NHANES II	1976-1980	25.16	13.95
NHANES III	1988-1994	26.40	21.62

[a]The surveys are as follows: National Health Examination Survey I (NHES I), National Health and Nutrition Examination Survey I (NHANES I), National Health and Nutrition Examination Survey II (NHANES II), and National Health and Nutrition Examination Survey III (NHANES III). Survey weights are employed in all computations.

[b]Weight in kilograms divided by height in meters squared.

[c]Percentage with body mass index equal to or greater than 30.

[d]In computations with NHES, two pounds are subtracted from actual weight since examined persons were weighed with clothing.

Table 2

Definitions, Means, and Standard Deviations of Variables[a]

Variable	Definition	Mean and Standard Deviation[a]
Body mass index	Weight in kilograms divided by height in meters squared	26.015 (4.959)
Obese	Dichotomous variable that equals 1 if body mass index is equal to or greater than 30	0.175 (0.380)
Black non-Hispanic	Dichotomous variable that equals 1 if respondent is black but not Hispanic	0.092 (0.288)
Hispanic	Dichotomous variable that equals 1 if respondent is Hispanic	0.085 (0.279)
Other race	Dichotomous variable if respondent's race is other than white or black	0.033 (0.179)
Male	Dichotomous variable that equals 1 if respondent is male	0.499 (0.500)
Some high school	Dichotomous variable that equals 1 if respondent completed at least 9 years but less than 12 years of formal schooling	0.092 (0.289)
High school graduate	Dichotomous variable that equals 1 if respondent completed exactly 12 years of formal schooling	0.330 (0.470)
Some college	Dichotomous variable that equals 1 if respondent completed at least 13 years but less than 16 years of formal schooling	0.262 (0.440)
College graduate	Dichotomous variable that equals 1 if respondent graduated from college	0.263 (0.440)
Married	Dichotomous variable that equals 1 if respondent is married	0.613 (0.487)
Divorced	Dichotomous variable that equals 1 if respondent is divorced or separated	0.089 (0.284)
Widowed	Dichotomous variable that equals 1 if respondent is widowed	0.066 (0.249)
Household income	Real household income in thousands of 1982-84 dollars	29.460 (24.627)
Age	Age of respondent	43.381 (17.119)
Time	Time in years, 1984 equals one	9.547 (4.243)
Restaurants	Number of fast-food restaurants and full-service restaurants per ten thousand persons in respondent's state of residence[b]	13.252 (1.529)

Table 2 (continued)

Definitions, Means, and Standard Deviations of Variables[a]

Variable	Definition	Mean and Standard Deviation
Fast-food price	Real fast-food meal price in respondent's state of residence in 1982-84 dollars[b]	2.903 (0.220)
Full-service restaurant price	Real full-service restaurant meal price in respondent's state of residence in 1982-84 dollars[b]	5.971 (1.172)
Food at home price	Real food at home price in respondent's state of residence in 1982-84 dollars: weighted average of prices of 13 food items, weights are shares of each item in total food expenditures based on expenditure patterns of midmanagement (middle-income) households[b]	1.258 (0.121)
Cigarette price	Real cigarette price in respondent's state of residence in 1982-84 dollars	1.287 (0.257)
Private	Dichotomous variable that equals 1 if smoking is prohibited in private workplaces in respondent's state of residence	0.343 (0.475)
Government	Dichotomous variable that equals 1 if smoking is prohibited in state and local government workplaces in respondent's state of residence	0.564 (0.496)
Restaurant	Dichotomous variable that equals 1 if smoking is prohibited in restaurants in respondent's state of residence	0.546 (0.498)
Other	Dichotomous variable that equals 1 if smoking is prohibited in other public places such as elevators, public transportation, and theaters in respondent's state of residence	0.688 (0.463)
Hourly wage[c]	Age-race-gender-education-and marital-status-specific expected real hourly wage rate in 1982-84 dollars in respondent's state of residence: real hourly wage rate of employed persons according to these characteristics multiplied by probability of employment according to the same characteristics	7.146 (3.319)
Weekly hours[c]	Age-race-gender-education-and marital-status-specific expected weekly hours of work in respondent's state of residence: weekly hours of work of employed persons according to these characteristics multiplied by probability of employment according to the same characteristics	30.429 (8.609)

[a]Standard deviation in parenthesis. Sample size is 1,111,074 except for hourly wage and weekly hours where sample size is 722,090. BRFSS sample weights are used in calculating the mean and standard deviation.

[b]See text for more details.

[c]Mean and standard deviation pertain to people 25 through 64 years of age.

Table 3

Body Mass Index Regressions, Persons 18 Years of Age and Older

Independent Variables	Dependent Variable: BMI		
	(1)	(2)	(3)
Black	1.635	1.638	1.635
	(57.29)	(57.59)	(57.36)
Hispanic	0.717	0.737	0.720
	(25.33)	(26.06)	(25.50)
Other race	-0.422	-0.405	-0.420
	(-7.39)	(-7.12)	(-7.39)
Male	0.890	0.890	0.891
	(54.66)	(54.39)	(54.61)
Some high school	-0.109	-0.109	-0.111
	(-3.48)	(-3.49)	(-3.55)
High school graduate	-0.507	-0.503	-0.509
	(-17.32)	(-17.17)	(-17.40)
Some college	-0.582	-0.572	-0.583
	(-19.45)	(-19.14)	(-19.51)
College graduate	-1.153	-1.150	-1.154
	(-35.75)	(-35.67)	(-35.84)
Married	0.190	0.186	0.190
	(12.19)	(11.95)	(12.18)
Divorced	-0.412	-0.411	-0.412
	(-19.91)	(-19.86)	(-19.94)
Widowed	0.267	0.262	0.267
	(10.15)	(9.98)	(10.16)
Household income	-0.034	-0.035	-0.034
	(-33.08)	(-32.88)	(-33.05)
Household income squared	0.0002	0.0002	0.0002
	(22.80)	(23.12)	(22.80)
Age	0.345	0.346	0.345
	(164.84)	(165.72)	(164.91)
Age squared	-0.003	-0.003	-0.003
	(-153.32)	(-153.94)	(-153.42)
Time	0.085		0.046
	(11.25)		(3.89)
Time squared	0.003		0.004
	(7.59)		(8.27)
Restaurants (full-service + fast food)		0.660	0.203
		(9.58)	(4.04)
Restaurants squared		-0.012	-0.006
		(-5.23)	(-4.31)

Table 3 (continued)

Body Mass Index Regressions, Persons 18 Years of Age and Older

Independent Variables	Dependent Variable: BMI		
Fast food restaurant price		-1.312	-0.481
		(-1.75)	(-0.94)
Fast food restaurant price		0.149	0.058
squared		(1.21)	(0.69)
Full service restaurant price		-0.705	-0.177
		(-4.45)	(-1.65)
Full service restaurant price		0.051	0.017
squared		(4.22)	(2.14)
Food at home price		-5.890	-2.581
		(-3.67)	(-2.26)
Food at home price squared		2.052	0.871
		(3.60)	(2.06)
Cigarette price		0.320	0.738
		(0.89)	(2.62)
Cigarette price squared		0.052	-0.228
		(0.45)	(-2.48)
Private		0.020	-0.042
		(0.50)	(-1.59)
Government		0.118	0.030
		(1.67)	(0.65)
Restaurant		-0.026	-0.039
		(-0.47)	(-0.96)
Other		0.051	0.019
		(0.95)	(0.49)
R-square	0.082	0.081	0.082
F-statistic	1480.75	1242.38	1226.43
Sample size	1,111,074	1,111,074	1,111,074

Note: All regressions include state dummies. t-ratios are in parentheses. Huber (1967) or robust standard errors on which they are based allow for state/year clustering. Intercepts are not shown.

Table 4

Obese Regressions, Persons 18 Years of Age and Older

Independent Variables	Dependent Variable: Obese		
	(1)	(2)	(3)
Black	0.089	0.089	0.089
	(43.51)	(43.68)	(43.51)
Hispanic	0.026	0.027	0.026
	(13.37)	(14.01)	(13.48)
Other race	-0.018	-0.017	-0.018
	(-5.23)	(-4.96)	(-5.23)
Male	-0.002	-0.003	-0.002
	(-2.49)	(-2.53)	(-2.47)
Some high school	-0.011	-0.011	-0.011
	(-4.42)	(-4.45)	(-4.50)
High school graduate	-0.044	-0.043	-0.044
	(-19.47)	(-19.40)	(-19.56)
Some college	-0.049	-0.049	-0.049
	(-21.40)	(-21.20)	(-21.47)
College graduate	-0.084	-0.084	-0.084
	(-34.27)	(-34.30)	(-34.38)
Married	0.004	0.004	0.004
	(3.44)	(3.29)	(3.44)
Divorced	-0.029	-0.029	-0.029
	(-20.31)	(-20.26)	(-20.34)
Widowed	0.010	0.010	0.010
	(5.38)	(5.25)	(5.39)
Household income	-0.003	-0.003	-0.003
	(-35.72)	(-35.56)	(-35.64)
Household income squared	0.0000	0.0000	0.0000
	(26.04)	(26.32)	(25.99)
Age	0.018	0.018	0.018
	(113.83)	(114.45)	(113.91)
Age squared	-0.0002	-0.0002	-0.0002
	(-110.12)	(-110.61)	(-110.22)
Time	0.004		0.001
	(6.95)		(1.44)
Time squared	0.0002		0.0003
	(7.53)		(8.14)
Restaurants (full-service + fast food)		0.039	0.014
		(8.29)	(3.71)
Restaurants squared		-0.001	-0.0004
		(-4.41)	(-3.73)

Table 4 (continued)

Obese Regressions, Persons 18 Years of Age and Older

Independent Variables	Dependent Variable: Obese		
Fast food restaurant price		-0.047	-0.001
		(-0.78)	(-0.02)
Fast food restaurant price squared		0.004	-0.001
		(0.40)	(-0.16)
Full service restaurant price		-0.050	-0.019
		(-4.09)	(-1.96)
Full service restaurant price squared		0.004	0.002
		(3.94)	(2.32)
Food at home price		-0.420	-0.208
		(-3.74)	(-2.12)
Food at home price squared		0.148	0.074
		(3.66)	(2.02)
Cigarette price		0.020	0.058
		(0.81)	(2.79)
Cigarette price squared		0.004	-0.017
		(0.51)	(-2.60)
Private		0.001	-0.003
		(0.25)	(-1.15)
Government		0.001	-0.004
		(0.12)	(-1.25)
Restaurant		0.0005	-0.0003
		(0.11)	(-0.10)
Other		0.008	0.006
		(1.97)	(1.76)
R-square	0.042	0.041	0.042
F-statistic	726.13	608.45	601.97
Sample size	1,111,074	1,111,074	1,111,074

Note: All regressions include state dummies. t-ratios are in parentheses. Huber (1967) or robust standard errors on which they are based allow for state/year clustering. Intercepts are not shown.

Table 5

Elasticities of Body Mass Index and the Probability of Being Obese with Respect to Selected Variables[a]

Independent Variable	Body Mass Index	Obesity Probability
Restaurants	0.174	0.946
Fast-food restaurant price	-0.050	-0.394
Full-service restaurant price	-0.022	-0.076
Food at home price	-0.035	-0.342
Cigarette price	0.022	0.223

[a]Computed at weighted sample means.

Table 6

Persons 25 through 64 Years of Age, Real Hourly Wage or Weekly Hours Worked Included

Independent Variable	Dependent Variable: BMI			
	(1)	(2)	(3)	(4)
Hourly wage	-0.023	-0.034		
	(-1.37)	(-2.07)		
Hourly wage squared	0.009	0.009		
	(9.23)	(9.60)		
Weekly hours			-0.150	-0.152
			(-20.21)	(-20.41)
Weekly hours squared			0.003	0.003
			(25.21)	(25.23)
Include time and time squared	No	Yes	No	Yes
R-square	0.073	0.074	0.074	0.075
F-statistic	705.00	696.95	717.13	708.84
Sample size	722,090	722,090	722,090	722,090

Independent Variable	Dependent Variable: Obese			
	(1)	(2)	(3)	(4)
Hourly wage	0.005	0.004		
	(4.74)	(4.01)		
Hourly wage squared	0.0002	0.0002		
	(3.99)	(4.41)		
Weekly hours			-0.005	-0.005
			(-11.12)	(-11.31)
Weekly hours squared			0.0001	0.0001
			(15.58)	(15.59)
Include time and time squared	No	Yes	No	Yes
R-square	0.041	0.041	0.041	0.041
F-statistic	377.59	373.48	380.29	376.22
Sample size	722,090	722,090	722,090	722,090

Table 7

Impacts of Selected Factors on Body Mass Index and Percentage Obese,
Persons 18 Years of Age and Older, 1984-1999

Factor	Body Mass Index Observed Change = 2.13			Obese Observed Change[a] = 12.99		
	(1)	(2)	(3)	(1)	(2)	(3)
Race/Ethnicity	0.08	0.08	0.08	0.35	0.36	0.35
Schooling	-0.06	-0.06	-0.06	-0.42	-0.42	-0.42
Marital status	-0.03	-0.03	-0.03	-0.13	-0.13	-0.13
Age	0.23	0.23	0.23	1.13	1.14	1.13
Household income	-0.09	-0.08	-0.08	-0.50	-0.50	-0.50
Trend	2.06		1.73	12.39		9.79
Restaurants		1.46	0.21		8.77	1.54
Fast-food restaurant price		0.09	0.03		0.48	0.17
Full-service restaurant price		0.08	-0.02		0.49	-0.09
Food at home price		0.13	0.06		0.86	0.41
Cigarette price		0.44	0.09		2.96	0.88
Clean indoor air laws		0.09	-0.02		0.57	-0.04
Total predicted change	2.06	2.42	2.23	12.82	14.57	13.09

[a]In percentage points.

Table 8

Impacts of Selected Factors on Body Mass Index, Percentage Overweight, and Percentage Obese, Persons 25 through 64 Years of Age, 1984-1999

Factor	Body Mass Index Observed Change = 2.05				Obese Observed Change[a] = 13.45			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Race/Ethnicity	0.10	0.10	0.09	0.09	0.48	0.46	0.43	0.42
Schooling	-0.10	-0.09	-0.07	-0.07	-0.67	-0.66	-0.50	-0.50
Marital status	-0.03	-0.03	-0.03	-0.03	-0.14	-0.14	-0.18	-0.18
Age	0.10	0.10	0.10	0.10	0.56	0.55	0.56	0.56
Household income	-0.09	-0.09	-0.08	-0.08	-0.49	-0.50	-0.44	-0.46
Trend		1.80		1.77		9.77		9.58
Restaurants	1.55	0.26	1.56	0.29	9.39	2.20	9.49	2.37
Fast-food restaurant price	0.10	0.04	0.10	0.04	0.53	0.23	0.49	0.23
Full-service restaurant price	0.08	-0.02	0.08	-0.01	0.53	-0.04	0.57	0.00
Food at home price	0.15	0.08	0.14	0.07	0.94	0.49	0.90	0.43
Cigarette price	0.37	0.02	0.44	0.09	2.71	0.69	3.12	1.09
Clean indoor air laws	0.09	-0.02	0.09	-0.02	0.62	0.02	0.61	0.03
Hourly wage	0.11	0.11			0.73	0.69		
Weekly hours			0.02	0.02			0.29	0.26
Total Predicted change	2.43	2.25	2.46	2.26	15.18	13.77	15.36	13.84

[a]In percentage points.

Table 9

Impacts of Selected Factors on Body Mass Index and Percentage Obese
NHES I – NHANES II

A. Persons 18 Years of Age and Older

Factor	Body Mass Index Observed Change = 0.25			Obese Observed Change[a] =1.22		
	(1)	(2)	(3)	(1)	(2)	(3)
Schooling	-0.18	-0.18	-0.18	-1.39	-1.39	-1.40
Marital status	-0.02	-0.02	-0.02	-0.10	-0.10	-0.10
Age	-0.07	-0.07	-0.07	-0.33	-0.33	-0.33
Family income	-0.19	-0.20	-0.20	-1.54	-1.54	-1.54
Trend	2.42		2.01	14.4		11.19
Restaurants		0.23	0.05		1.35	0.34
Food at home price		-0.02	-0.02		-0.09	-0.05
Cigarette price		-0.00	-0.00		-0.02	-0.02
Clean indoor air laws		0.01	-0.00		0.24	0.12
Total predicted change	1.96	-0.24	1.58	11.03	-1.91	8.21

B. Persons 25 through 64 Years of Age

Factor	Body Mass Index Observed Change = 0.40				Obese Observed Change[a] = 1.96			
	(1)	(2)	(3)	(4)	(1)	(2)	(3)	(4)
Schooling	-0.25	-0.25	-0.17	-0.17	-2.05	-2.01	-1.56	-1.54
Marital status	-0.02	-0.02	-0.02	-0.02	-0.13	-0.13	-0.13	-0.13
Age	0.01	0.01	0.02	0.02	0.07	0.07	0.08	0.08
Family income	-0.22	-0.22	-0.22	-0.22	-1.74	-1.72	-1.73	-1.72
Trend		2.09		2.05		11.19		10.91
Restaurants	0.24	0.06	0.24	0.61	1.47	0.46	1.49	0.49
Food at home price	-0.02	-0.03	-0.02	-0.02	-0.16	-0.11	-0.14	-0.08
Cigarette price	-0.00	-0.00	-0.00	-0.00	-0.02	-0.02	-0.02	-0.03
Clean indoor air laws	0.01	-0.00	0.01	-0.00	0.22	0.13	0.21	0.12
Hourly wage	0.05	0.04			0.38	0.35		
Weekly hours			-0.01	-0.01			-0.04	-0.04
Total predicted change	-0.21	1.67	-0.18	1.69	-1.96	8.20	-1.83	8.07

Figure 1
Trends in Body Mass Index and Percentage Obese, Persons 18 Years of Age and Older, Behavioral Risk Factor Surveillance System, 1984-1999