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An economic analysis of adult obesity: results from the Behavioral Risk Factor Surveillance System

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Abstract

This paper examines the factors that may be responsible for the 50% increase in the number of obese adults in the US since the late 1970s. We employ the 1984–1999 Behavioral Risk Factor Surveillance System, augmented with state level measures pertaining to the per capita number of fast-food and full-service restaurants, the prices of a meal in each type of restaurant, food consumed at home, cigarettes, and alcohol, and clean indoor air laws. Our main results are that these variables have the expected effects on obesity and explain a substantial amount of its trend.

JEL classification: I12; I18

Keywords: Obesity; Body mass index; Fast-food restaurant

1. Introduction

Since the late 1970s, the number of obese adults in the US has grown by over 50%. 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

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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 has been associated with an increase in the demand for convenience food (food requiring minimal preparation time) and consumption in fast-food restaurants. Home time also has fallen and the consumption of the two types of food just mentioned has risen because the slow growth in income among certain groups has increased their labor market time.

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. Some of the changes just mentioned, especially the growth in the availability of fast-food restaurants, may have been stimulated by increases in the value of female time.

To study the determinants of adult obesity and related outcomes, we employ micro-level data from the 1984–1999 Behavioral Risk Factor Surveillance System (BRFSS). 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 the price of alcohol (a potential determinant of weight outcomes given the high caloric content of beer, wine, and distilled spirits). 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.

2. Background

The significance of research on obesity and sedentary lifestyle is highlighted by the adverse health outcomes and costs associated with these behaviors and by the level and growth of obesity rates. 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 US. By comparison, the mortality associated with tobacco, alcohol and illicit drugs is about 400,000, 100,000, and 20,000 deaths per year, respectively. Wolf and Colditz (1998) estimate that in 1995 the costs of obesity were US$ 99.2 billion, which was 5.7% 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.

Until recently, obesity in the US 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 National Heart, Lung, and Blood Institute, National Institutes of Health (1998), a BMI value of between 20 and 22 kg/m^2 is "ideal" for adults regardless of gender in the sense that mortality and morbidity risks are minimized in this range. Persons with BMI $\geq 30\,kg/m^2$ are classified as obese.

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
NHANES 99	1999–2000	27.85	29.57

[a] The surveys are as follows: First National Health Examination Survey (NHES I), First National Health and Nutrition Examination Survey (NHANES I), Second National Health and Nutrition Examination Survey (NHANES II), Third National Health and Nutrition Examination Survey (NHANES III) and National Health and Nutrition Examination Survey 1999–2000 (NHANES 99). Survey weights are employed in all computations.

[b] Weight in kilograms divided by height in meters squared. Actual weights and heights are used in calculation.

[c] Percentage with body mass index $\geq 30\,kg/m^2$.

[d] In computations with NHES, 2 lbs. are subtracted from actual weight since examined persons were weighed with clothing.

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 2000 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, the Third National Health and Nutrition Examination Survey (NHANES III) between 1988 and 1994, and the National Health and Nutrition Examination Survey 1999–2000 (NHANES 99).[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 13-year period, the percentage obese rose from approximately 14 to 22%. Absent any increase in population, this implies that the number of obese Americans grew by roughly 55%. At the same time, BMI rose by $1.24\,kg/m^2$ or by 5%, which represents a 6 lb weight gain for a woman or man of average height. The corresponding figures between 1960–1961 (the mid-year of NHES I) and 1978 were a 10% increase in the number of obese persons, and a 1% increase in BMI. Data from the most recent NHANES survey suggest that the sharp upward trend in obesity between NHANES II and III continued through the year 2000.

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

[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 years 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 US 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.

(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 1976–1994 and in the National Longitudinal Survey of Youth (NLSY) for the period from 1982 to 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.

Trends in aggregate time series data and four studies by economists (Cawley, 1999; Ruhm, 2000; Lakdawalla and Philipson, 2002; Cutler et al., 2003) provide some insights concerning the causes of the upward trend in obesity. 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 non-market 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% (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.

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 or slow growth in real income of certain groups and increases in hours of work and labor force participation rates by most groups, especially women (see Chou et al., 2002 for a detailed discussion of these trends). The 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, 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 (Pinkowish, 1999). The real price of cigarettes rose by 164% 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% of the population resided in states that restrict smoking in the workplace. By 1999, this figure stood at 42% (Centers for Disease Control and Prevention (CDC) 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 for the period from 1981 to 1996. His price variable incorporates variations over time and among the four major geographic regions of the US. 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. Cutler et al. (2003) present evidence that reductions in the time costs of preparing meals at home for certain groups in the population contribute to an increase in BMI for those groups. They attribute the reduction in the daily time allocated to meal preparation (their measure of the time cost) to technological advances. Their results are based on very aggregate data and do not directly take account of the growth in fast-food and full-service restaurants.

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, grocery prices, and the time required to prepare a meal at home 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 including time costs ignores the dramatic shift away from the consumption of meals at home during the past 30 years.

3. Analytical framework

In Chou et al. (2002), we develop a simple behavioral model of the determinants of obesity using standard economic tools. Obesity is a function of an individual's energy balance over a number of time periods or ages. The energy balance in a given period is the difference between calories consumed and expended in that period. In addition to this cumulative energy balance, age, gender, race, ethnicity, and genetic factors unique to an individual help determine weight outcomes by influencing the process by which energy balances are translated into changes in body mass. A behavioral model of obesity must explain the determinants of calories consumed and calories expended.

Since no one desires to be obese, it is useful to consider obesity as the byproduct of other goals in the context of Becker's (1965) household production function model of consumer behavior. This model 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 produce more fundamental commodities that enter their utility functions. Three such commodities are health, which depends in part by consuming the appropriate diet and engaging in physical exercise, the enjoyment of eating palatable food, and the entertainment provided by dining with family and friends in restaurants or at home.

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.

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.

These considerations suggest reduced form equations or demand functions for calories consumed and expended and for cigarette smoking. The last variable is included 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, which we do not explicitly model. The demand functions depend on a set of variables specified below and consisting mainly of prices and income. Substitution of these equations into the structural equation for BMI or for the probability of being obese yields a reduced form equation for the outcome at issue.

Reduced form determinants include hours of work or the hourly wage rate; family income; a vector of money 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, the price of cigarettes, and the price of alcohol; years of formal schooling completed; and marital status. With regard to the roles of variables not discussed so far, 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 palatable food and food consumed at "upscale" full-service restaurants are rich in calories.

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. 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. The price of alcohol also is included because alcohol has a high caloric content. The empirical evidence that increased alcohol consumption contributes to weight gain is, however, mixed (for example, Prentice, 1995; Kahn et al., 1997). 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. 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. 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.

4. Empirical implementation

To investigate the determinants of body mass index and obesity, we employ repeated cross sections from the Behavioral Risk Factor Surveillance System for the years 1984–1999. The BRFSS consists of annual telephone surveys of persons of age 18 years and older conducted by state health departments in collaboration with the Centers for Disease Control and Prevention. 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.[3] The average number of interviews per state ranged from

[3] The states in the BRFSS in 1984 were Arizona, California, Idaho, Illinois, Indiana, Minnesota, Montana, North Carolina, Ohio, Rhode Island, South Carolina, Tennessee, Utah, West Virginia, and Wisconsin. In 1985, Connecticut, the District of Columbia, Florida, Georgia, Kentucky Missouri, New York, and North Dakota entered the survey. Alabama, Hawaii, Massachusetts, and New Mexico joined in 1986. Maine, Maryland, Nebraska, New Hampshire, South Dakota, Texas, and Washington joined in 1987. Iowa, Michigan, and Oklahoma joined in 1988. Oregon, Pennsylvania, and Vermont joined in 1989. Colorado, Delaware, Louisiana, Mississippi, and Virginia joined in 1990. Alaska, Arkansas, and New Jersey joined in 1991. Kansas and Nevada joined in 1992. Wyoming joined in 1994. The first year in which all 50 states and the District of Columbia were in the BRFSS was 1996 because Rhode Island, which joined the survey in 1984, was not in it in 1994 and because the District of Columbia, which joined in 1985, was absent in 1995.

approximately 800 in 1984 to 1800 in 1990, and to 3000 in 1999. These state stratified cluster samples are used by CDC to make national and 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 5 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. CDC makes national estimates from the BRFSS beginning in 1990 when 45 states participated in the survey. To maximize variation in the state-specific regressors, we include data for all years in the regressions. Preliminary results obtained when the sample was restricted to the years 1987–1999 were fairly similar to those obtained for the entire period. 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.[4]

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 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.[5] 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.[6] 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 in the BRFSS all exceed values computed from reported weight and height. For BMI, the corrected figure is 26.01 kg/m^2, and the uncorrected figure is 25.40 kg/m^2. According to the corrected data, 17.54% of the population is obese, compared to an uncorrected figure of 13.75%. 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.

[4] Nevertheless, we also estimated weighted regressions in preliminary analysis and obtained results similar to those in the unweighted regressions.

[5] 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.

[6] We eliminated the extremely small number of BRFSS respondents with an uncorrected BMI of <11 or $>140\ kg/m^2$.

Table 2
Definitions, means, and standard deviations of variables[a]

Variable	Definition	Mean and standard deviation
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 $\geq 30\,kg/m^2$	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 1982–1984 dollars	29.460 (24.627)
Age	Age of respondent	43.381 (17.119)
Restaurants	Number of fast-food restaurants and full-service restaurants per 10,000 persons in respondent's state of residence[b]	13.252 (1.529)
Fast-food price	Real fast-food meal price in respondent's state of residence in 1982–1984 dollars[b]	2.903 (0.220)
Full-service restaurant price	Real full-service restaurant meal price in respondent's state of residence in 1982–1984 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 mid-management (middle-income) households[b]	1.258 (0.121)
Cigarette price	Real cigarette price in respondent's state of residence in 1982–1984 dollars[b]	1.287 (0.257)
Alcohol price	Real alcohol price in respondent's state of residence in 1982–1984 dollars: weighted average of prices of pure ounce of ethanol in beer, wine, and spirits; weights are shares of each item in total alcohol consumption[b]	1.065 (0.170)
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)

[a] Standard deviations are in parentheses. Sample size is 1,111,074. BRFSS sample weights are used in calculating the mean and standard deviation.
[b] See text for more details.

The trends in corrected BMI and the corrected percentages of the population obese in the BRFSS are plotted in Fig. 1. The values of BMI and obese are computed based on BRFSS sampling weights which produce nationally representative figures as of 1990. Between 1984 and 1999, BMI increased by 2.13 kg/m^2 or by 9%, 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 obtained from actual heights and weights in NHANES. For example, 24.00% of the population was obese in 1999 based on the BRFSS compared to 29.57% based on NHANES 99.[7] Nevertheless, annual rates of change in the BRFSS appear to be comparable to those in NHANES. This holds even though the BRFSS data prior to 1990 may not be nationally representative. For example, in the 13-year period spanned by the mid-years of NHANES II and NHANES III, BMI grew at an annually compounded rate of 0.4% per year, and the percentage obese grew at an annually compounded rate of 3.4% per year. The corresponding increases in the 15-year period spanned by the BRFSS were 0.5% per year for BMI and 5.3% per year for obesity.[8]

The roles of all the independent variables in Table 2 in body mass and obesity outcomes were discussed in Section 3. 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.[9]

The number of fast-food restaurants and the number of full-service restaurants are taken from the 1982, 1987, 1992, and 1997 *Census of Retail Trade* (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.[10] 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

[7] The latter figure is taken from Table 1. That figure and all other data in Table 1 are based on actual heights and weights in NHANES.

[8] The more rapid growth rate in obesity in the BRFSS is not a function of the small number of states in that survey in 1984. Between 1991 and 1999, obesity grew at an annually compounded rate of 5.4% per year in the BRFSS. The corresponding growth rate in NHANES between NHANES III and NHANES 99 was 3.6% per year.

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

[10] In 1997, the Bureau of the Census replaced the SIC system with the North American Classification System (NAICS). A discussion of the algorithm employed to estimate fast-food and full-service restaurants in that year is available on request.

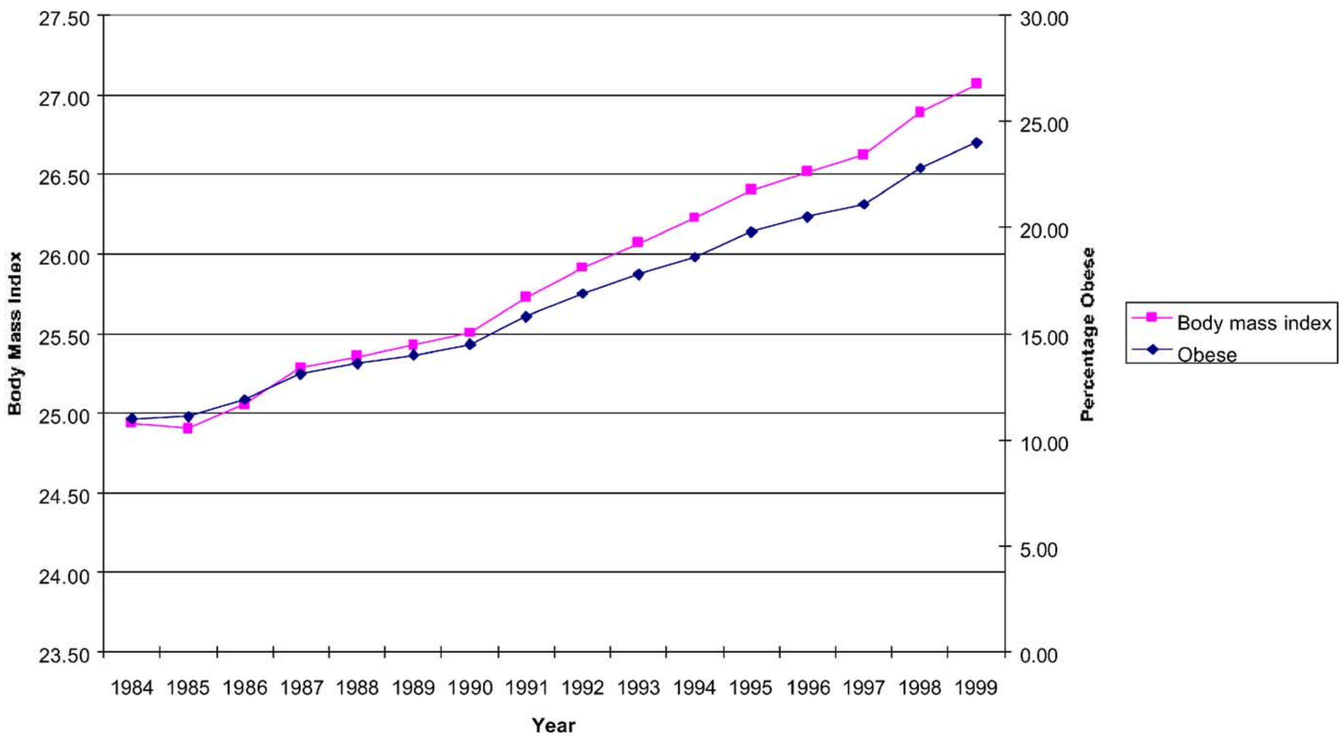

Fig. 1. Trends in body mass index and percentage obese, persons 18 years of age and older, Behavioral Risk Factor Surveillance System, 1984–1999.

fast-food and full-service restaurants and employ the per capita number in the regressions in Section 5.

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 US$ 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 US$ 1.50 to the smallest category, and an average cost of US$ 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.[11]

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 of a household whose head holds a mid-management position. The budget shares of each of the three fast-food items were equal to each other in the period from 1984 to 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 US as a whole (1982–1984 = 1). All other money prices and money income in the regressions are deflated by the CPI.[12]

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 13 prices, where the weights are the average expenditure shares of these items as reported by the ACCRA during the years from 1984 to 1999. Since the weights are fixed over time, the resulting price is a Laspeyres food at home price level.[13]

[11] In that year, the categories are less than US$ 2.00, 2.00–4.99, 5.00–9.99, and 10.00 and over.

[12] 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 mid-management 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.

[13] A detailed description of the food at home price is available on request. The same comment applies to the alcohol price defined further.

The price of alcohol also is taken from the ACCRA survey. It is given as a weighted average of the prices of beer, wine, and distilled spirits. This price is constructed by converting beer, wine, and distilled spirits prices into the price per ounce of pure ethanol in each beverage. These three prices were then averaged using the national fractions of total ethanol consumption accounted for by each beverage in 1990 as weights.

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.[14] 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 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. We accomplish this aim by multiplying the coefficients of all regressors by national trends in these variables between 1984 and 1999 and between 1960–1961 (the mid-year of NHES I) and 1978 (the mid-year of NHANES II). 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. That is, we do include trend terms in the regressions. In preliminary research we found that the multicollinearity between trend measures and the state-specific variables made it very difficult to disentangle their separate effects. Moreover, the effects of adding states to the BRFSS over time confound the interpretation of trend terms. We realize that the omission of trend measures is controversial and limits our ability to interpret estimated relationships as being causal. We do think that it is illuminating to investigate what proportion of the recent dramatic increase in obesity can be explained by changes in our variables without a trend. We also think it is illuminating to see how well we can backcast weight outcomes between 1960–1961 and 1978.[15] A conservative interpretation of our goal is that we seek to explain trends in an accounting, rather than in a causal, sense.

5. Results

Table 3 contains ordinary least squares regressions of body mass index and the probability of being obese, for persons 18 years of age and older. Robust or Huber (1967) standard errors,

[14] 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.

[15] Regressions with linear and quadratic trend terms are presented and discussed in Chou et al. (2002).

Table 3
Body mass index and obese regressions, persons 18 years of age and older

Independent variable	Dependent variable: BMI	Dependent variable: obese
Black	1.638 (57.58)	0.089 (43.67)
Hispanic	0.737 (26.09)	0.027 (14.01)
Other race	−0.406 (−7.14)	−0.017 (−4.98)
Male	0.890 (54.41)	−0.003 (−2.53)
Some high school	−0.110 (−3.50)	−0.011 (−4.46)
High school graduate	−0.503 (−17.21)	−0.043 (−19.42)
Some college	−0.572 (−19.17)	−0.049 (−21.23)
College graduate	−1.150 (−35.68)	−0.084 (−34.29)
Married	0.187 (11.99)	0.004 (3.33)
Divorced	−0.411 (−19.86)	−0.029 (−20.27)
Widowed	0.262 (10.00)	0.010 (5.26)
Household income	−0.035 (−32.95)	−0.003 (−35.65)
Household income squared	0.0002 (23.18)	0.0000 (26.39)
Age	0.346 (165.73)	0.018 (114.52)
Age squared	−0.003 (−153.92)	−0.0002 (−110.67)
Restaurants (full-service + fast-food)	0.631 (9.41)	0.037 (8.02)
Restaurants squared	−0.011 (−5.17)	−0.001 (−4.23)
Fast-food restaurant price	−1.216 (−1.67)	−0.034 (−0.58)
Fast-food restaurant price squared	0.135 (1.13)	0.002 (0.20)
Full-service restaurant price	−0.687 (−4.28)	−0.047 (−3.83)
Full-service restaurant price squared	0.050 (3.97)	0.003 (3.57)
Food at home price	−6.462 (−3.37)	−0.530 (−4.28)
Food at home price squared	2.244 (3.12)	0.191 (4.12)
Cigarette price	0.486 (1.37)	0.032 (1.32)
Cigarette price squared	0.009 (0.08)	0.001 (0.11)
Alcohol price	1.140 (1.29)	0.145 (2.35)
Alcohol price squared	−0.734 (−1.93)	−0.080 (−2.98)
Private	0.015 (0.38)	0.0004 (0.13)
Government	0.115 (1.63)	−0.0000 (0.00)
Restaurant	−0.020 (−0.36)	0.001 (0.21)
Other	0.054 (0.97)	0.008 (1.96)
R^2	0.081	0.041
F-statistic	1212.21	593.94
Sample size	1111074	1111074

Note: All regressions include state dummies. The *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.

which allow for state/year clustering, are obtained.[16] In preliminary regressions we found evidence that most of the continuous variables had non-linear effects. Therefore, we employ

[16] Standard errors of state-specific variables computed by clustering by state do not differ dramatically from those computed by clustering by state/year and do not lead to different results with regard to statistical significance. We emphasize results with state/year clustering because state clustering distorts the standard errors of the state dummies. The number of restaurants and the full-service restaurant price in some years are obtained from interpolations and extrapolations. Empirically, the standard deviation of a given variable in a year in which it is predicted is very similar to its standard deviation in a surrounding year in which it is available. This obviates the need to adjust standard errors for the presence of predicted values in some years.

a quadratic specification for each of these variables. Recent research by economists dealing with obesity estimates separate models by gender, race, and in some cases ethnicity (for example, Averett and Korenman, 1996; Lakdawalla and Philipson, 2002; Cawley, 2004). We do not pursue this approach because the studies at issue focus on the relationship between obesity and labor market outcomes specific to an individual. We do not directly consider this relationship. Moreover, our aim is to provide an explanation of general trends in obesity rather than in trends for specific groups in the population.

The two regressions in the table have low explanatory power, with R^2 ranging from 4 to 8%. The main reason for this result is that body mass index and obesity have large genetic components. In this context it should be emphasized 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.[17] But there is little reason to believe that the state-specific variables that we consider are correlated with heredity. Of course, the regression disturbance term also may reflect tastes for different types of food. Our working hypothesis is that the mix of food consumption changes over time due to changes in prices and related determinants rather than to changes in tastes.

Focusing on the effects of the individual characteristics, 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 years.[18] 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.

[17] Suppose that u is an unobserved determinant of schooling and g an unobserved determinant of obesity. 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 in the US based on data in the Minnesota Twin Registry, see Behrman and Rosenzweig (2001).

[18] According to Stevens et al. (1987) the relative mortality associated with greater BMI declines with age. Therefore, an adjustment for this factor would produce a peak in BMI at an earlier age.

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 impact of income on the probability of being obese is more substantial. Evaluated at sample means, a 10% increase in income is associated with a 0.5 percentage point decline in the percentage obese from 17.5 to 17.0%. In a fixed population, the number of obese people falls by 2%. It should be noted that the magnitude of the income effect may be overestimated due to the reverse causality from obesity to income (Averett and Korenman, 1996; Cawley, 2004).

Despite the relatively large number of state-specific 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 means. 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. One possible explanation is that smokers substitute consumption of food at home for consumption in restaurants in states that restrict smoking at the latter site. 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 weight outcomes, with the obesity effect achieving significance.

The absence of a clear pattern in the effects of clean indoor air laws may reflect in part their endogeneity. Evans et al. (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. In our context, state fixed effects may control for unobserved forces that influence smoking, obesity, and the enactment of clean indoor air laws.

Table 4 contains elasticities of BMI with respect to the continuous state-specific variables at the points of weighted sample means. It also contains percentage point changes in the probability of being obese associated with 10% changes in the state-specific variables.[19] 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 six times larger than the absolute value of the income elasticity. When the probability of being obese is the outcome, the effects in Table 4 are much more substantial. For example, a 10% increase in the number of restaurants increases the probability of being obese by 1.4 percentage points. Put differently, evaluated at sample means, a 10% increase

[19] Let π be the probability of being obese and let x be a continuous regressor. We fit an equation of the form $\pi = \alpha x + \beta x^2$, where the intercept and other independent variables are suppressed. Hence, $(\partial\pi/\partial(\ln x)) = (\alpha + 2\beta x)x$, and $100\partial\pi = 100(\alpha + 2\beta x)x\,\partial(\ln x)$. Column 2 of Table 2 contains estimates of $100\partial\pi$ evaluated at the mean of x and a value of $\partial(\ln x)$ equal to 0.10.

Table 4
Elasticities of body mass index and percentage point change in the probability of being obese with respect to selected variables[a]

Independent variable	Body mass index	Obesity probability[b]
Restaurants	0.173	1.390
Fast-food restaurant price	−0.048	−0.650
Full-service restaurant price	−0.021	−0.667
Food at home price	−0.039	−0.622
Cigarette price	0.025	0.445
Alcohol price	−0.017	−0.271

[a] Computed at weighted sample means.

[b] Figures in the second column show 100 times the change in the probability of being obese associated with a 10% change in a given independent variable. See footnote 19 for more details.

in the per capita number of restaurants is associated with a growth in the percentage obese from 17.5 to 18.9%. In a fixed population, the number of obese people rises by 8%. Note, however, that national or state-specific time varying unobservable changes in the demand for caloric intakes might be correlated with changes in obesity and the number of restaurants. In that case, the impact of the fast-food restaurants may be overestimated.

With regard to the three direct food price variables, the greatest response to BMI occurs when the real fast-food restaurant price varies. The elasticity of BMI with respect to this price is −0.05. When obesity is the outcome, the fast-food and full-service restaurant price effects are about the same. A 10% increase in each price is associated with a 0.7 percentage point decrease in the percentage obese. Like Cawley (1999) and Lakdawalla and Philipson (2002), we find that weight outcomes rise when food at home prices decline. The elasticity of BMI with respect to this price is larger in absolute value than the full-service restaurant price elasticity but smaller than the fast-food price elasticity. When obesity is the outcome, the magnitude of the food at home price effect is slightly smaller than those of the other two food prices.

The positive cigarette price effects in Table 4 indicate substitution between calories and nicotine. The magnitude of the cigarette price effect in the obesity equation is approximately two-thirds as large as any of the three food price effects in that equation. The elasticity of BMI with respect to the cigarette price is larger than full-service restaurant 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. Finally, the negative alcohol price effects in Table 4 imply that calories and alcohol are complements. The magnitudes of these effects, however, are the smallest among the variables that we consider.

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

Table 5
Impacts of selected factors on body mass index and percentage obese, persons 18 years of age and older, 1984–1999

Factor	Body mass index obese observed change = 2.13	Observed change[a] = 12.99
Race/ethnicity	0.08	0.36
Schooling	−0.06	−0.42
Marital status	−0.03	−0.13
Age	0.23	1.14
Household income	−0.08	−0.49
Restaurants	1.40	8.37
Fast-food restaurant price	0.09	0.47
Full-service restaurant price	0.05	0.33
Food at home price	0.14	0.95
Cigarette price	0.48	3.24
Alcohol price	0.01	0.09
Clean indoor air laws	0.09	0.54
Total predicted change	2.38	14.25

[a] In percentage points.

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.

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. Table 5 addresses the latter issue by examining how well selected models predict the increases in obesity and related outcomes between 1984 and 1999. The estimates in Table 5 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. Note that national values of state-specific variables in 1984 are population-weighted averages of values for all states rather than for states in the BRFSS in that year. Note also that our conclusions are not altered when 1987 or 1990 is taken as the initial year.

During the period at issue BMI rose from 24.94 to 27.07 kg/m^2, and the percentage of the population obese rose from 11.05 to 24.04%. Our regression models slightly overpredict both outcomes. 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.

The increase in the per capita number of restaurants makes the largest contribution to trends in weight outcomes, accounting for 61% of the actual growth in BMI and 65% 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. Taken alone, the decline in each price was modest and explains little of the trend. The largest contribution is made by the food at home price and contributes 7% to the trends in BMI and obesity. A somewhat different picture emerges if the three food price effects are aggregated into a single component. The contribution of this component is between one-half and three-fifths as large as that of the cigarette price and accounts for approximately 12% of the trend in weight outcomes. The rising prevalence of clean indoor air laws has about the same impact as the reduction in the fast-food restaurant price. The slight reduction in the price of alcohol has the smallest impact on the growth in BMI and the rise in the percentage obese.

As shown in Table 1, BMI and the percentage obese were very stable between 1960–1961 (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 2 years in an attempt to explain why weight outcomes did not rise in that 18-year period. The results of this exercise are contained in Table 6. 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 1958 and 1963 Census of 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 and alcohol prices are based on the series in the Consumer Price Index (Bureau of the Census, various years).

Our model predicts very small reductions in the outcomes compared to the very small increases that actually took place. On the other hand, Chou et al. (2002) show that backcasts with a model that replaces the state-specific variables with trend terms 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. 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

Table 6
Impacts of selected factors on body mass index and percentage obese, persons 18 years of age and older (NHES I and NHANES II)

Factor	Body mass index observed change = 0.25	Obese observed change[a] = 1.22
Schooling	−0.18	−1.39
Marital status	−0.02	−0.10
Age	−0.07	−0.33
Family income	−0.20	−1.54
Restaurants	0.22	1.29
Food at home price	−0.02	−0.03
Cigarette price	0.00	−0.02
Alcohol price	0.04	1.17
Clean indoor air laws	0.01	0.22
Total predicted change	−0.22	−0.74

[a] In percentage points.

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. This suggests that it also is missing a variable that can offset the positive impact of declines in smoking on obesity.

6. 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, the price of alcohol, and clean indoor air laws. 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.

Three results stand out. The first is the large positive effects 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 non-market time. 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 and related result is that downward trends in food prices account for part of the upward trend in weight outcomes. In one sense this simply verifies the law of the downward sloping demand function. But there are more subtle aspects of this finding since the location in which food is consumed appears to matter. In particular, technological innovations and the realization of economies of scale that led to reductions in the real fast-food restaurant price may have been stimulated in part by efforts to accommodate the increased demand for consumption of food away from home.

The third result that stands out is the positive cigarette price effect. 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, all three 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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