

Childhood Obesity: Trends and Potential Causes

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Introduction

The increase in childhood obesity worldwide has garnered much recent attention, from healthcare professionals, health policy experts, children's advocates, and parents. There is much concern that today's overweight and obese children, will turn into tomorrow's overweight and obese adults, with all the health problems and health care costs associated with obesity. In this essay, we are concerned with documenting the trends in children's obesity and in examining the potential underlying causes of the increase in obesity.

In what follows, we discuss commonly used definitions of overweight and obesity and discuss the benefits and potential problems with these. We document the international trends in adult and childhood obesity. Then we turn to a more in-depth analysis of obesity in the United States. Here we pay particular attention to the timing of the increase in obesity rates in adults and children. Later when we turn to an analysis of the potential causes of obesity, we are interested in whether the changes that may potentially drive the increase in obesity follow a time-series pattern that coincides with the observed increase in obesity.

As a starting point, we review the literature on energy intake and energy expenditure. Much of this literature examines whether children who eat certain types of foods, or engage in certain activities, are more likely to be overweight than similar peers who do not do these things. We describe this literature as giving insight into what affects children's "energy balance." In general, this literature supports the idea that children who eat more "empty calories" and expend fewer calories through physical activity, are more likely to be obese than other children.

In the next section, we ask what in the United States has changed over the last three decades that may have upset this energy balance equation. Have there been changes that have increased children's exposure to the things that the literature above suggests contribute to

obesity? In particular, we examine changes in the food market, changes in the built environment, changes in schools and child care settings, and changes in the role of parents. We examine whether the changes in the environment in which children are being raised follow a time-series pattern that makes it likely that these changes are causes of the increase in children's obesity rates.

I. Definitions of and Trends in Obesity

In order to think about the potential causes of the increase in childhood obesity, it is important to understand how we measure obesity, and what the actual trends have been in this measure of obesity. In this section we briefly discuss how childhood obesity is defined, and examine trends in measured obesity for both children and adults. Additionally, we examine how the U.S. experience compares with that in other countries.

A. Measuring Overweight and Obesity

Typically, obesity and overweight are defined as having a body-mass-index (BMI) above a particular cutoff point. BMI is defined as weight in kilograms divided by height in meters squared (kg/m^2).¹ According to guidelines in National Institutes of Health, an adult is considered underweight if his BMI is less than 18.5, overweight if his BMI is 25 or more, and obese if his BMI is 30 or more.²

Use of the BMI to assess overweight and obesity in children is more controversial. Since children are growing, there may be a looser link between adiposity or “true fatness” and the ratio of their weight to their height. However, Dietz and Bellizzi, reporting on a conference convened by the International Obesity Task Force, noted that BMI “offered a reasonable measure with which to assess fatness in children and adolescents.”³ Additionally, they conclude that a BMI

above the 85th percentile for a child's age and sex group is likely to accord with the adult definition of overweight, and above the 95th percentile with the adult definition of obese.⁴ Thus, overweight and obesity in children are defined by their having a BMI above a given age and sex specific percentile cutoff. These age and sex specific percentile cutoffs have been set for a base population surveyed in the early 1970's, before obesity began to increase.⁵ This percentile cutoff yields a specific, fixed, number for each age-sex group.

Below we will use these cutoffs to define obesity for our sample of U.S. children in the National Health and Nutrition Examination Surveys (NHANES).⁶ We will see an increase in measured obesity over time if more children in each of the NHANES surveys have a BMI above this fixed cutoff number. The NHANES data are ideal for tracking BMI changes in the population because the survey is representative of the United States population. In addition, information is gathered both from questionnaires and from direct medical examination. For example, the individuals included in the medical examination module are weighed and measured by trained professionals. The first NHANES data set was collected in 1971-1974; the second data set was collected from 1976-1980; the third was collected from 1988-1994; and fourth was collected from 1999-2002. Therefore, the NHANES provides us with a nationally representative data set of the United States that includes consistently measured indicators of height and weight over the last three decades.

Before analyzing changes in obesity in the United States over time, we first briefly examine changes in other countries.

B. International Trends in Obesity

Obesity is not just a problem in the United States. However, international comparisons in obesity rates and trends in these rates are complicated, because, as described above, defining

obesity is complicated. BMI may not be comparable across different countries as the relationship between “true fatness” and height and weight may differ for people in different environments. For example, some groups may simply have denser body composition than others. These definitions are particularly complicated when it comes to making comparisons of obesity in children across different countries. As discussed above, children’s obesity is typically measured by their BMI compared to age-and-sex specific growth charts, because children are growing and their body composition is continuously changing. If age-sex specific growth patterns are different in Botswana than they are in the United States, then obesity definitions based on the same BMI cutoffs are unlikely to yield useful comparisons. Nonetheless, a growing body of literature examining specific populations has concluded that obesity is increasing worldwide.

A 1998 World Health Organization (WHO) report gives an overview of changes in obesity among *adults* in many countries around the world.⁷ Table 1 presents obesity rates for several countries, culled from a number of tables in the WHO report.⁸ These show the percent obese for men and women, for different time periods. Figure 1 presents the fraction obese over time for various age groups in the United States. Comparing table 1 and figure 1, the fraction obese in the United States is generally higher than those in the other countries listed. By 1995, 15 percent and 16.5 percent of English men and women, respectively, are obese. In the United States (in the nearest time period for which data are available), the percent obese was over 20 percent for men and women combined.⁹ The former German Democratic Republic has obesity rates that are similar to those in the United States for similar years. For all these countries, the percentage of the population that is obese is increasing, although the rates are still quite low in China, Japan, Finland, Sweden and the Netherlands.

As mentioned before, measuring obesity in children, and making comparisons in obesity across very different types of people is difficult. Nonetheless, many studies of individual countries have noted increases in childhood obesity in recent years. Kalies et al. shows that obesity rates have increased from 1.8 to 2.8 percent among pre-school children in Germany.¹⁰ Among 7-11 year olds in England, the prevalence of overweight and obesity increased from below 10 percent for both boys and girls in the mid-1970s to above 20% for girls and above 15 percent for boys by 1998.¹¹ In China, the prevalence of obesity in urban areas increased among 2-6 year old children from 1.5 percent in 1989 to 12.6 percent in 1997. In rural areas in China over this same time period, obesity rates fell.¹²

The literature makes clear that obesity among children is increasing worldwide. The patterns are different, in expected ways, between developing and developed countries. In developing countries, obesity may co-exist with under-nutrition, with children in the relatively affluent urban areas more likely to be obese than their rural counterparts.

For many reasons it is difficult to compare these data to those from the United States to see if we see similar characteristics in the changes in obesity over time. Below, we will discuss in detail the changes in the distribution of BMI in the United States. It would be very interesting to know whether the distribution of BMI changes in similar ways across different countries, in addition to comparing rates of obesity. Furthermore, where the data exist, to examine whether the time patterns in obesity coincide with changes in the environment that are likely to produce increases in obesity – a question we explore in the U.S. case below. Understanding these time patterns might help pinpoint the drivers of childhood obesity across different countries.

C. Obesity in the United States

Obesity rates have been increasing for all age groups in the United States over the last 30 years. Figure 1 shows the fraction of the U.S. population, by age group, that is obese based on the BMI cutoffs described above.¹³ From 1971 to 1974, about five percent of children, age 2 to 19 years, were obese. A slightly higher percentage were obese in 1976-1980. Between 1980 and 1988-1994, we see a near doubling of the fraction of children who qualify as obese. By the 1999-2002 period, nearly 15 percent of children are considered obese. Although the rates of obesity are higher for older children in every survey, all age groups show an increase in obesity over the time period.

The figure also shows the fraction of adults, age 20-70, who are considered obese in each of these years. It is clear that a higher proportion of adults are obese than children in any given time period, and that adult obesity is also increasing over the period shown.

Obesity rates are increasing for both males and females over this time period. By 1999-2002, obesity rates for boys and girls are nearly identical for 2-19 year olds. For adults, on the other hand, women have higher obesity rates than men.¹⁴

It is important to keep in mind that the increasing obesity among children is related to the increasing obesity among adults. Fifteen year olds in 1971 are thirty-two year olds by 1988. Obese children are much more likely than normal weight children to be obese adults. In fact, even obesity in very young children is correlated with higher rates of adult obesity: a study from the late 1990s shows that 52 percent of children who are obese between the ages of 3 and 6 are obese at age 25, while only 12 percent of normal and underweight 3 to 6 year olds are obese at age 25.¹⁵

The fraction of the population that is obese increases with age, but the relationship between age and obesity has been changing over the last three decades. Note in Figure 1 that for

each year of data, obesity generally increases with age. We can also see that for every age, the fraction of the population that is obese is higher in later years. However, across the years, obesity rates increased faster for older children. This suggests that the relationship between age and obesity is changing (becoming steeper) over time. Consider, for example, projections about what fraction of people who were 10 years old in 1971 would be obese by the time they reached the age of forty, in 2001. If we based our prediction on the data available in 1971-1974, we would predict that between 10-15 percent of 40 year olds in 2001 would be obese. If we turn to the 1999-2002 data and ask what fraction of 40 year-olds are, in fact, obese, we find the answer is close to 30 percent. This suggests that the “true” relationship between age and obesity is much steeper today than in the past. Said differently, people’s obesity is increasing with age more quickly than one would have predicted based on data from the 1970s. This has important implications for trying to predict what fraction of the population will have obesity related health problems as the population ages.

The timing of the increase in obesity in the U.S. is important, because it may help us to identify the changes that led to the increase. Figure 1 shows that fraction of the population that was obese, for both children and adults, is fairly stable between 1971-1974 and 1976-1980. This suggests that we should look closely for factors that might affect obesity that changed between 1980 and 1988, and continued to change in the 1990s. In what follows, we will examine whether potential causes of the increase in childhood obesity follow the right patterns over time to explain the trends in children’s obesity.

Before we move on to discussing the possible causes of the increase in childhood obesity, we want to document more features of the changes in obesity over time. Figure 2 demonstrates that obesity is higher among minority children and among low-income children.¹⁶ While obesity

increased for all three of these groups of children, it went up more for children in low-income families than for children overall, and increased the most for African-American children.

In addition to examining changes in obesity rates it is important to examine how the distribution of BMI has shifted over time. Obesity rates may be misleading because we may see large changes in obesity rates for small changes in BMI, depending on how BMI is distributed. For example, suppose that there is a large group of children with BMIs just below the obesity cutoff in one year. These children gain a few pounds and thus tip over into the obese category. Obesity rates would increase, even though the underlying health of the population did not change very much. This is also important in comparing obesity rates between groups. For example, if obesity rates were higher among low-income children simply because there was a slightly higher fraction of children with BMIs above the obesity cutoff, we might not expect to see differences in obesity rates translating into differences in health outcomes. Thus, it is important to understand how the distribution of BMI differs over time, and between groups within time period, in addition to how simple rates of obesity differ.

By 1999-2002, not only was a higher fraction of children obese, the obese were heavier than in the past. In addition to showing the fraction of all, low-income, and African American children who are obese, Figure 2 lists the average BMI among the obese for each of these groups. Average BMI among all obese children did not increase a great deal between 1971-1974 and 1988-1994, implying that the increase in obesity rates was mostly due to a higher fraction of children “tipping” over the obesity cutoff. By 1999-2002, however, average BMI had increased among obese children. The increase in average BMI observed over the whole period indicates that a child who was 4’6” tall went from weighing about 113.6 pounds to weighing 116.1 pounds. Figures 3 and 4 show additional features of the changes in the BMI distribution. These

figures graph the fraction of the population that is overweight (but not obese) and the fraction obese for adults and children, respectively. The graphs also list the BMI at the median of the distribution (half of the people are heavier) and BMI at the 95th percentile of the distribution (5 percent of the people are heavier). After 1976-1980, the fraction overweight and the fraction obese increase for both adults and children. However, the fraction of the population that is obese increases more rapidly. Similarly, while the median BMI increases after 1980, the BMI at the 95th percentile increases more quickly. For an adult woman who is 5'4" tall, BMI at the median implies that she weighed about 143.3 pounds in 1971-1974. By 1999-2002, she weighed 157.3 pounds, a weight gain of about 14 pounds, or a 9.8 percent weight gain. For a 5'4" tall woman with BMI at the 95th percentile, her weight increased from 197.5 to 231.9 pounds over the same period, a 34.4 pound or 17.4 percent weight gain. For children, the difference in the median and upper tail weight gain is even more striking. A 4'6" child with the median BMI gained about 4.6 pounds over this period, for a 6.3 percent increase (73.4 to 78.0 pounds). However, a child at the 95th percentile gained about 19 pounds, for a 17.5 percent weight gain (108.3 to 127.3 pounds).

BMI is becoming more "unequally distributed," or, said differently, the heavy are getting heavier. Figures 2, 3 and 4 demonstrate that by 1999-2002, the increase in obesity rates is not merely an artifact of having a fixed cutoff that defines obesity. We have not simply witnessed a change in the fraction of the population that is slightly below to slightly above this fixed cutoff. If that is all that had happened, we might even have seen average BMI among the obese fall by the end of the period. Additionally, differences in obesity rates across race and income groups do not appear to be due solely to small differences in the distribution of BMI among these groups. Again, if differences in obesity rates between African-American children and the rest of

the population were merely due to a slightly higher fraction of the population above the cutoff in the former group, differences in obesity rates would not necessarily be correlated to differences in underlying health. That does not appear to be what generates differences in obesity rates between different groups in the population: African-American children who are obese are heavier than the overall population of obese children within each of the surveys.

These figures, in addition to assuring us that the increase in obesity rates is not merely an artifact of having a fixed cutoff point, tell us something interesting about the problem of obesity. Namely, it is not evenly distributed. Obesity is not evenly distributed across socio-demographic groups. In addition, BMI is becoming more unequally distributed over time. It is not the case that everyone has gained 10 percent of his body weight compared to people in earlier decades, it appears that that the heavy have gotten much heavier. This may have implications for the costs of the obesity epidemic – they are also unlikely to be evenly distributed. This pattern of changes in the BMI distribution make obesity appear to have much in common with other diseases: everyone may be exposed to a given change in the environment, but only those with a susceptibility to the given disease will come down with it. For those with a susceptibility to obesity, the conditions appear to be right for their disease to flourish.

II. A Question of Energy Balance

As we have just seen, overweight and obesity is clearly rising. This increase is apparent in both children and adults, and not only in the United States, but in many other countries as well. Less clear are the causes of this increase, although the basic physiology of weight change is well understood. When energy intake exceeds energy expenditure, weight gain will result. That said, there do also exist endocrinological or neurological syndromes (including Prader

Willi, Klunefeler's, Frohlich's, Lawrence Mood Biedl, Klein-Levin, and Mauriac syndromes) that can lead to overweight. While these are often tested for, especially in cases of childhood obesity, it has been estimated that less than five percent of obesity cases result from these "endogenous" factors.¹⁷

At the same time, genetics have also been found to play an important role in obesity. Recent studies have concluded that about 25 to 40 percent of BMI is heritable.¹⁸ Identical twins raised apart, for example, have been found to have a correlation in BMI of about 0.7, which is only slightly lower than that of twins raised together.¹⁹ Of course, a change in genes cannot explain the recent increase in childhood overweight and obesity, as the gene pool is not rapidly changing. However, it does appear that certain individuals may have a higher genetic susceptibility to weight gain. Thus, when identical twins are subjected to an overfeeding regimen, the correlation of the weight gain within twin pairs is significantly higher than that between pairs.²⁰ Therefore, even though genetics are an important factor in BMI, the main focus must be on changes in energy balance.

Maintaining a stable weight requires a delicate balance between energy intake and energy expenditures. Nonetheless, very young children seem quite capable of adjusting their intake to match their outflow, but at a certain point this apparently innate ability seems to be lost.²¹ Rather than intake being based on energy needs, it is influenced by external cues, such as the amount of food presented.²² Thus, a large portion of the existing literature on childhood obesity focuses on the role of energy intake, with most analyzing a particular source.

A. Studies of Energy Intake

Fast food is a common subject of such studies of energy intake. Cross-sectional studies have clearly established that individuals consuming fast food meals have higher energy intake

with lower nutritional values.²³ However, such a finding does not guarantee that children consuming more fast food will be more likely to be overweight. In fact, Ebbeling et. al. find that while both overweight and lean adolescents consume more calories when eating fast food, the lean compensate for that energy intake, while the overweight do not.²⁴ A recent longitudinal study of 8 to 12 year old girls found that those eating more fast food (i.e. two or more times per week) at baseline, when 96 percent of study subjects were lean, were observed to have larger weight gains at a three-year follow-up.²⁵ A major drawback to this study is that it covers only middle-class, white females. Additionally, while the longitudinal nature of the study is an improvement over cross-sectional studies, it still does not conclusively prove a causal effect of fast food. Unobserved characteristics of the girls may be correlated with both fast-food consumption and weight gain, with this unobserved factor being the true causal culprit.

Another frequently studied source of energy is sweet beverages, mainly soft drinks but also including juice. As was the case with fast food, studies generally first establish that drinking these beverages results in higher overall energy intake. Additionally, several studies have found a positive relationship between overweight and soft drink consumption.²⁶ Results on the role of juice have been somewhat more mixed, however, with cross-sectional studies finding a relationship but some longitudinal studies not.²⁷ More recently, however, a longitudinal study of pre-schoolers has found a positive relationship between all sweet beverages (including soda, juice and other fruit drinks) and overweight.²⁸ Another recent study looks at repeated cross-sections of 5th graders in one school, and finds a positive, but not significant, relationship between sweetened beverage consumption and BMI.²⁹ Finally, another recent study uses a longitudinal design similar to that of the Thompson et. al. fast food study described above.

Children age 9 to 14 in 1996 were followed annually through 1998. For both boys and girls, consumption of sugar-added beverages implied small increases in BMI over the year.³⁰

Another specific source of energy intake that has been studied is snacks. Snack foods tend to be energy dense, implying that snacking may increase overall energy intake. However, snacking does not appear to be a contributor to childhood overweight. In a simple cross-sectional study comparing obese and non-obese adolescents, Bandini et.al. find that energy intake from snacks is similar across the two groups.³¹ They conclude that obese adolescents eat no more “junk” food than non-obese adolescents, and thus that the source of the energy imbalance for the obese must lie elsewhere. A recent longitudinal study comes to a similar conclusion. Phillips et. al. collect information from 8 to 12 year-old girls annually over a ten-year period.³² They find no relationship between the consumption of snack foods (such as chips, baked goods and candy) and BMI, although as in the beverage-specific studies reviewed above, they do find a relationship between BMI and soda.

B. Studies of Energy Expenditure

The other, equally important, side of the energy balance equation is energy expenditures. Energy is expended not only by physical activity, but also through dietary thermogenesis and the basal metabolic rate (BMR). For sedentary adults, the first of these is responsible for 30 percent of total energy expenditure, the second just 10 percent, while BMR accounts for the remaining 60 percent.³³ Several studies examine whether a low BMR is responsible for overweight in children. For example, studying both obese and non-obese adolescents Bandini, Schoeller and Dietz find that BMR is not reduced in the already obese, and that lowered energy expenditure through BMR is thus not the cause of maintained obesity in adolescents.³⁴

Given the lack of evidence for the role of BMR on childhood overweight and obesity, it is important to focus on physical activity (or lack thereof). Studies focused on the relationship between physical activity and BMI have had mixed results.³⁵ The difficulty in finding a consistent negative effect of physical activity on BMI is possibly due to the fact that BMI is a potentially poor measure of adiposity in the presence of significant lean muscle mass. Evidence of this hypothesis is found in a study of 12-year-old French children. Looking at both BMI and waist circumference, Klein-Platet et. al. find a significant negative effect of physical activity on waist circumference for both boys and girls.³⁶ However, a relationship with BMI was observed only for girls. While results from cross-sectional studies have been somewhat mixed, longitudinal studies have found a relationship between increases in activity and decreases in BMI.³⁷

Much stronger results have been found for the relationship between sedentary activities and overweight and obesity, especially television viewing. On the one hand, sedentary activities may crowd out more active pursuits, making this type of study seem completely parallel to the activity studies. However, time spent in sedentary activity may be more easily measured, than is physical activity, where intensity matters. That said, at least one study that investigated the association between television watching and physical activity found none.³⁸ Interestingly, while it did find a relationship with computer use, reading and homework time, these sedentary activities were associated with higher levels of physical activity.

Dietz and Gortmaker produced the canonical study on the role of television in childhood obesity, finding that each additional hour of television increased the prevalence of obesity by 2 percent.³⁹ They make clear that there are several possible pathways for television viewing to affect weight. First, of course, is the possibility discussed above that physical activity is

squeezed out. Second, television advertising may increase children's desire for, and ultimately consumption of, energy dense snack foods. Third, watching television may be a complementary activity to snacking, leading to higher energy intake among children watching television. Later work by Klesges, Shelton, and Klesges even concluded that children's metabolic rate was actually lower while watching television than when at rest.⁴⁰ However, this result has not been replicated, with later studies finding no effect.⁴¹

The overall literature on the relationship between television viewing and physical activity and overweight might be described as mixed. For example, while a number of studies have found a positive relationship between television and childhood obesity, Robinson et. al. find only a weak relationship (although Dietz points out several potential methodological problems with this study), and Vandewater et. al. find no relationship.⁴² These mixed results, though, tend to come from observational or prospective studies. Experimental studies, however, have consistently found that reducing children's television watching lowers their BMI.⁴³ Given that these interventional studies can establish causality, while the others do not, it seems reasonable to conclude that television watching does contribute to childhood obesity, despite the overall mixed results of past studies.

C. Studies of Additional Correlates of Obesity

Overall, then, much of the literature on the correlates of childhood obesity can be thought of as trying to identify something that is expected to impact either the child's energy intake or energy expenditure. Another strain of the literature, however, simply documents characteristics correlated with overweight, but either does not or can not determine the effect of this characteristic on the energy balance equation. Thus, there are a number of studies documenting that children from certain demographics groups are more likely to be overweight. As was shown

above, using data from the NHANES, African-American children have a higher incidence of obesity, as do lower income children. Using data from the National Longitudinal Survey of Youth, Strauss and Pollack also demonstrate that both African-American and Hispanic children are more likely to be overweight than white children.⁴⁴ They also find higher income to reduce overweight among whites only, with results for Hispanics being insignificant and results for African Americans being slightly positive. They also document regional differences, with children in the South and the West being most likely to be overweight. This study did not find a significant difference between rural and urban children. However, a recent study of Pennsylvania school children found nearly 20 percent of 7th graders from rural districts to be overweight, compared to just 16 percent for urban districts.⁴⁵

While most of these additional studies focus on basic demographic characteristics, there is another repeatedly analyzed characteristic that does not clearly line up with the energy balance equation. It is the effect of having been breastfed as an infant. Beginning with Kramer, many cross-sectional studies have found that older children are more likely to be lean if they were breastfed.⁴⁶ However, other studies have found somewhat more mixed results.⁴⁷ More recently, though, Arenz et. al. in a meta-analysis conclude that breastfeeding does seem to have a consistent negative effect on obesity, albeit a small one.⁴⁸ As Dietz makes clear, the mechanism by which infant breastfeeding may affect weight at later ages is not certain.⁴⁹ Possibilities include an endocrine response to breastmilk, the greater maternal discretion over feeding amounts in bottle feeding, or even an effect on future food preferences. It is also possible that the relationship is purely an artifact of the cross-sectional study design. That is, the types of mothers who do and do not breastfeed may practice different nutritional and/or activity standards for their children when they are older. Some evidence for this possibility can be found in

Nelson, Gordon-Larsen, and Adair, who confirm the past cross-sectional findings using data from the National Longitudinal Study of Adolescent Health.⁵⁰ However, when using sibling pairs to control for unobserved maternal factors they find that there is no effect of breastfeeding on weight. There are two things to keep in mind when evaluating results based on sibling differences, though. First, sibling pairs who were both breastfed or both bottlefed will be dropped from the analysis. The resulting sample may thus be too small to identify statistically significant effects on weight. Second, with sibling pairs where only one is breastfed, there is the issue of why the mother made different decisions. It may be the case that the decision was related to factors that will ultimately affect the children's weight.

Given the above evidence from studies focused on energy balance, the question remains as to how these results inform the issue of the increase in childhood overweight and obesity over the past several decades. First, it is clear that the majority of the studies do not determine clear causality. Rather, many reveal cross-sectional correlations. Of the longitudinal studies, many are carried out on relatively unrepresentative samples (e.g. middle class girls from a specific region, etc.), making it unclear whether the results are broadly applicable. Even for those studies for which we have a lot of representative, longitudinal evidence (e.g. the role of television) we need to ask whether the time patterns of the exposure match up with the time patterns seen in childhood obesity. Recall from the previous section that it was relatively stable from 1971 through 1980, but had risen by 1988 and continued to rise through 2002. In the next section, we consider the possible role played by the food market, by the built environment, by schools and child care, and by parents. In particular, we look at the timing of changes in these factors and at what effect these forces might have on energy balance. Finally, we discuss some existing studies

on their role in increasing childhood overweight and obesity. The articles that follow in this journal will then take an in-depth look at each of the factors.

III. Changes in the Determinants of Energy Balance

A range of environmental changes may have affected children's energy balance over the past several decades. When interacted with a potential genetic susceptibility, these environmental changes may have contributed to the increase in childhood overweight and obesity. In this section we consider four possible changes, each of which is discussed in more detail in a following paper. We begin with changes in the food market, followed by changes in the built environment. We then turn our attention to schools and child care and conclude by analyzing the role of parents.

A. Changes in the Food Market

In the previous section, we saw that there is a general consensus in the literature that there is a correlation between some types of energy intake and childhood obesity and overweight. Probably the strongest evidence was for the role of soft drinks, followed by slightly mixed results on the role of fast food, with there being very little evidence for a specific effect of snack foods. Even without one clear "smoking gun" food in terms of energy intake, it is clear that more food, without a concomitant increase in energy expenditure will result in weight gain. Thus, it seems reasonable to investigate the timing of changes in the food market that might have contributed to the increase in childhood overweight and obesity. Putnam and Gerrior, in analyzing changes in the U.S. food supply show that overall consumption of carbonated soft drinks has increased markedly over time.⁵¹ Focusing just on regular (non-diet) sodas, overall consumption trended slightly upward in the 1970s, remained fairly stable in the early 1980s and

then exploded starting in 1987, continuing to rise steadily through the 1990s. Figure 5 illustrates this trend, superimposing children's obesity rates over the four periods for which NHANES data are available.

On the surface, the timing of the increase in soda consumption seems fairly promising as a contributor to the increase in childhood overweight and obesity. However, the trend is for overall consumption – if only adults were increasing soda consumption this correlation would be clearly spurious. However, French, Lin and Guthrie document that children's consumption has also risen, with the average intake more than doubling from 5 ounces to 12 ounces per day.⁵² Among those drinking soft drinks (a percentage that increased from 37 to 56), average consumption rose 50 percent, from 14 ounces to 21. Unfortunately this study has only the two data points, one from 1977/78 and one from 1994/98, making it impossible to pinpoint if the increase occurred mainly in the late 1980's as it did for overall soft drink consumption. To the extent that children's consumption did mirror the overall trends, however, and given the significant effect on obesity that has been found for soft drinks, increased consumption may have contributed to the recent trends in obesity. The question then becomes, "what led to an increase in soft drink consumption?" It is true that advertising on soft drinks has been increasing over time, at \$541 million in 1995 and \$799 million in 1999, an almost 50 percent increase.⁵³ Overall food-related advertising over this same period increased less than 20 percent, from \$9.8 billion to \$11.6 billion.

While it appears that beverage advertising has been growing disproportionately, the evidence on whether advertising increases overall consumption of a product (versus relative brand consumption) is somewhat mixed. There is evidence of advertising affecting preferences, though, even of children as young as 2-years-old.⁵⁴ In addition to noting this mixed evidence on

the overall demand effects of advertising, Zywicki, Holt and Ohlhausen argue directly against the idea the food advertising is a cause of increasing childhood obesity, arguing in part that there has been very little increase in children's exposure to advertising over time.⁵⁵ Taras and Gage, however, indicate that shorter commercials have increased the number of advertisements to which children are exposed, such that in 1993 children's programming had 11 percent more commercials per hour than it had in 1987.⁵⁶ Throughout the time period, about 50 percent of the ads were for foods and beverages. Interestingly, though, only a small fraction (about 6 percent) of the beverage advertising was for soft drinks. It is important to note, however, that this study (like most studies on children and advertising) focus on children's programming. Many children, though, are watching "adult" programming on television, and thus being exposed to the same advertisements as the general population.

Another possible source of the increase in soft drink consumption is the increase in food consumed away from home. French, Lin and Guthrie note that the share of soft drink consumption in restaurants (including fast food) increased by over 50 percent, while the share consumed at home declined by almost 25 percent.⁵⁷ This trend in soft drinks mirrors the overall trend in food away from home. Lin et. al. document that while the percentage of calories from food away from home was just 18 percent in the 1977-78 period, it had jumped to 27 percent by 1987-88 and by 1995 it had increased to 34 percent.⁵⁸ Thus, the increase in food away from home represents a major change in the food market. In fact, Chou et. al. claim that for adults, up to two-thirds of the increase in obesity since 1980 can be explained by the per capita increase in fast food restaurants over the time period.⁵⁹ However, their methodology does not rule out the possibility that the growth trends in both series are just coincidentally correlated.

Also looking at adults, Cutler et. al. argue that increasing fast food restaurants are just part and parcel of an overall change in technology, such that tastier treats are available at lower cost and higher convenience.⁶⁰ In fact, they point to snacking as the key source of increased energy intake for adults. As we saw earlier, though, there is very little evidence for a direct effect of snacking on children's obesity. The change in the food market that does remain in play, however, is portion size. As noted earlier, all but the youngest children will eat more when presented with larger portion sizes.⁶¹ Looking at convenience foods (both fast foods and other foods packaged for single-serving consumption), Young and Nestle document increases in portion sizes.⁶² For 181 products they can identify the introduction date of larger portions. Throughout the 1970s such introductions are quite low, at fewer than 10 for each half-decade. By the first half of the 1980s these introductions begin to increase, with about 20 introductions, and by the first half of the 1990s the number of introductions has more than doubled to over 40. By the last half of the decade there were over 60 introductions of new, larger portion sizes. This time pattern again fits relatively closely with the time pattern seen for increases in childhood obesity. Thus, a contributor to the increase in childhood overweight may not just be an increase in particular types of foods, such as sodas, but simply the change in the food market toward providing larger portion sizes.

Finally, no discussion of the food market would be complete without considering prices. Lakdawalla and Philipson, for example, argue that declines in the relative price of food have led to increased intake, and hence to increases in obesity.⁶³ They calculate that up to 40 percent of the adult increase in BMI since 1980 can be attributed to the increased demand for calories that results from lower prices. Within food groups, the consumer price index for food away from home grew only slightly more slowly than did that for food at home.⁶⁴ Starting with an index of

100 for the 1982 to 1984 period, the food at home index rose to 158.1 in 1997, while the food away from home index rose to 157, making price an unlikely primary cause of this shift in eating patterns. In general, it has been argued that energy-dense foods tend to be of lower cost than such foods as whole grains, fruits and vegetables.⁶⁵ However, based on scanner data, Reed, Frazao and Itskowitz conclude that it is possible to meet the daily recommendations of three servings of fruits and vegetables for just 64 cents.⁶⁶ They also note that while consumers may perceive fresh produce as more expensive than processed versions (i.e. canned, frozen, dried or juiced), when converted from a per-pound price to a per-serving price, 63 percent of fruits and 57 percent of vegetables were actually cheapest when purchased fresh. It is worth noting, however, that these prices do not take into account the implicit time costs associated with preparation of fresh foods. We will consider this idea below when we discuss the changing role of parents.

B. Changes in the Built Environment

We saw earlier that there is a strong theoretical relationship between physical activity and overweight. Although the empirical studies establishing this link are comparatively weak, it is worth investigating changes in children's physical activity. Historically, physical activity was not something one set out to do, it was simply part of life. In fact, Philipson and Posner argue that the long-run rise in adult obesity can be traced to technological changes that have made work much more sedentary.⁶⁷ Thus, rather than being paid to undertake physical activity, modern Americans must pay (either explicitly in gym fees, equipment costs, etc., or implicitly in foregone leisure) to be physically active. While attractive as a theory of historical trends and of differences between developing and developed countries, it provides little insight into the increase in childhood overweight and obesity over the past 30 years. Nonetheless, the basic insight that technological changes have resulted in daily living being less physically active can

be applied to children. In order to do that, it is necessary to examine changes to the neighborhoods in which children are growing up.

Sprawl results in more vehicle miles traveled per person.⁶⁸ Thus, with increasing sprawl, vehicle miles have increased. Daily vehicle miles traveled per household was fairly constant between 1977 and 1983, at about 33 and 32 respectively, before jumping up to 41 in 1990.⁶⁹ Changes in methodology do not allow comparisons to be made between the first two surveys and years after 1990. However, the 1990 data have been adjusted to allow such comparisons. This adjustment results in about 50 vehicle miles traveled per household for 1990. Then, it is clear that the increase continued in the early 1990s, before slowing in the latter half of the decade. The 1995 measure is 57, while that for 2001 is just 58. Of course, an increase in household vehicle miles traveled does not necessarily mean children are spending more time in the car. However, total miles traveled by those under 16 follows a pattern fairly similar to that of persons of all ages. The main difference being that the mileage is fairly steady between 1983 and 1990, while climbing slowly for all ages. Both groups then show large increases between 1990 and 1995 and are fairly stable in 2001.

Part of the increase in vehicle miles is the result of children no longer being able to walk or bike to school or other activities. In 1977, 15.8 percent of trips by children age 5 to 15 were by foot or bicycle. By 1990 this had fallen to 14.1 and then fell further to 9.9 percent by 1995.⁷⁰ A nationally representative survey in 2002 found that 53 percent of parents drove their children to school, with another 38 percent having children who took a school bus. Just 17 percent of parents said their children walked to school, while 5 percent had children who rode their bikes.⁷¹ Of those with children who did not walk or bike to school, the overwhelming majority, 66 percent, said the reason was that school is too far away. Almost equally common responses, at

17, 16 and 15 percent respectively were, “too much traffic and no safe walking route,” “fear of child being abducted,” and “not convenient for child to walk.” “Crime in the neighborhood” and “your children do not want to walk” both tallied a 6 percent response. Interestingly, 1 percent said that there was a “school policy against children walking to school.”

The 22 percent of children walking or riding bikes to school in 2002 represents a major decline from when their parents were children (presumably about 20 to 30 years earlier). Just over 70 percent of the parents reported they walked or biked to school as a child. Again, the increasing trend toward urban sprawl is presumably at least part of the explanation (i.e. school is too far away). In fact, a study of South Carolina schools found that children today were much less likely to walk to a school that had been built more recently. Schools built as recently as the 1960s had over 20 percent of their students walking to them. For those built in the 1970s this drops to under 15 percent, while for those built in the 1980s and 1990s less than 5 percent of students walk.⁷² Distance is not the only obstacle, however. In this study, children living within 1.5 miles of the school are eligible for bus transportation if the walking route is deemed hazardous. For schools built in the 1990s, over 25 percent of students receive such transportation, compared to just over 5 percent for schools built in the 1960s, while the fraction increases consistently by the decade the school was built.

Overall, then, it appears clear that trends in the built environment have resulted in more car trips, and fewer trips by foot or by bicycle. Most notably, less than a quarter of children walk or bike to school, compared to over two-thirds a generation ago. This trend appears to be due not only to lower density development that results in schools being further away from children’s homes, but also growth patterns that do not provide safe walking routes. In addition to losing this opportunity for some physical activity for children, it may have additional impacts on overall

physical activity. Cooper et. al. find that at least for British boys, walking to school was correlated with higher levels of activity in other parts of the day.⁷³ Of course, this relationship may well simply reflect that naturally more active boys prefer to walk to school or that walking to school is an indicator that *other* opportunities for physical activity are also close by, rather than being causal.

C. Changes in School and Child Care

Not only has children's method of getting to school changed, but the environment once they get there has changed as well. In particular, there have been changes in the types of foods and beverages available at school, as well as changes in physical education requirements. Recall from above that soft drink consumption has risen markedly over the past several decades. Some of this increase is due to the increased availability at school. Between 1977/78 and 1994/98, the share of soft drink consumption that took place in school cafeterias increased by 3 percent.⁷⁴ Much of the food available at schools is not sold in the cafeteria, however, but is sold in vending machines. Over that same period, the fraction of soft drink consumption that comes from vending machines increased by 48 percent. Additionally, student access to vending machines has increased from 61 to 67 percent in middle schools and 88 to 96 percent between 1994 and 2000.⁷⁵ Schools have found it to be quite lucrative to enter into exclusive "pouring rights" contracts with soft drink companies. In fact, in 2000 73 percent of high schools had such a contract, as did 58 percent of middle schools, and even 42 percent of elementary schools.⁷⁶ Additionally, many schools allow these companies to advertise on school grounds – 46 percent of high schools, and 29 and 13 percent of middle and elementary schools, respectively.

School vending machines do not just dispense soft drinks, but also snacks, while school stores and snack bars also sell soft drinks and snacks. In fact, among elementary schools with

such student access, over 50 percent sell cookies, crackers, cakes, pastries and salty snacks. The fraction grows to over 60 percent for middle schools and over 80 percent for high schools.⁷⁷ Additionally, school cafeterias also sell these products a la carte, in competition with the National School Lunch Program. Such competing foods are often an important part of the school budget, as most school food service programs must be self-supporting . These sales often do more than subsidize the food service program, however. Increasingly, schools are using money raised through competitive food sales to supplement general budgets. One change in budgetary pressure on schools is the increased focus on academic accountability. This increased focus has had the additional effect of squeezing out other areas of study, such as nutrition and physical education, and even reducing the time available for lunch.⁷⁸

There has been speculation that these changes in the school environment may have contributed to the increase in childhood overweight and obesity, but there are relatively few serious studies of the impact.⁷⁹ Anderson and Butcher link school financial pressures to availability of junk food in middle and high schools, and estimate that a 10 percentage point increase in the availability of junk food produces an average increase in BMI of 1 percent, while for adolescents with an overweight parent the effect is double.⁸⁰ Effects of this size can explain about a quarter of the increase in average BMI of adolescents over the 1990's. Schanzenbach focuses not on the competing foods in schools, but on the National School Lunch Program.⁸¹ She finds that for children entering kindergarten with similar obesity rates, those eating the school lunch are about 2 percentage points more likely to be overweight at the end of first grade. It is not clear, however, that there have been changes in the school lunch program that could explain the increase in obesity over time, although there has been a slight increase between 1991/92 and 1998/99 in the number of calories in an elementary school lunch, going from 715 to

738. For secondary school lunches, however, there has been a decline over this same period, from 820 to 798.⁸²

As just noted, it appears that physical activity has been squeezed out of schools to make room for more academics. The National Association of Early Childhood Specialists in State Departments of Education made a position statement recently on the importance of recess and free play, noting that forty percent of elementary schools have reduced, deleted or are considering deleting recess since 1989, when 90 percent of schools had some form of recess.⁸³ Trends in physical education at the high school level are a bit less clear, with enrollment moving up and down over the 1990s. The trend for daily PE attendance is generally downward, though, with about 42 percent reporting it in 1991, and just 29 percent by 2003.⁸⁴ More generally, MacPherson notes that since the late 1970s, children have seen a 25 percent drop in play and a 50 percent drop in unstructured outdoor activities.⁸⁵ One potential culprit is a reported increase in homework between 1981 and 1997, especially for the youngest students. Hofferth and Sandberg report that while time spent studying was up 20 percent overall, for children age 6 to 8 it increased by 146 percent.⁸⁶

Another source of a drop in unstructured play is the increasing number of children in child care centers after school. Figure 6 illustrates the basic trends in maternal employment for pre-school-age and for school-age children, again superimposing children's obesity rates over the four periods for which NHANES data are available. Note that the quality of child care used varies, so it is unclear whether being in child care per se impacts children's obesity. Nonetheless, it is clear that the potential for less physical activity, more sedentary activities, more sweet drinks and more energy-dense snacks exists when moving from parental care to a child care setting. Notice, however, that the increase in labor force participation appears fairly

continuous from 1970 through about 1988 before flattening out in the 1990s, with no sudden increase between 1980 and 1988. Despite the fact that the exact pattern of the change is not entirely consistent with the pattern of the increase in obesity, it remains worthwhile to investigate the changing role of parents more fully.

D. Changes in the Role of Parents

It is clear that a major change over the past thirty years is in the number of children with both parents (or their single parent) in the labor force. These changes in the home environment may provide an explanation for the increase in food away from home and pre-prepared foods observed over this time period, as families value convenience more highly. That is, the changes in the food market outlined above may be driven by consumer demand changes that stem from the increase in households with no full-time homemaker. Note, though, that studies on the effect of maternal employment on the quality of children's diets tend to find no relationship.⁸⁷

However, a more recent study that directly examines the effect of maternal employment on childhood obesity concludes that a 10 hour increase in average hours worked per week over a child's lifetime increases the probability that the child is obese by about 1 percentage point.⁸⁸ In this study, it is not the act of working, per se, that affects children's overweight and obesity, but rather the intensity of that work. This difference may explain why the previous studies found no real effect of work per se on children's diets and is in line with the idea that more time at work takes away from time spent preparing nutritious meals.

Alternatively, with less intensive work hours, mothers may spend more time supervising active play. Similarly, having two parents working full time may contribute to the trends away from walking to biking to school that we saw earlier, as it may just fit parents' schedules better

to drop the children off at school on the way to work. To the extent that maternal employment affects children's physical activity, rather than nutrition, both sets of studies may be reconciled.

Increasing maternal employment may also affect the incidence or length of breastfeeding. The labor force participation rate of married women with children under 1 was about 31 percent in 1975, but increased to 54 and 55 percent by 1990 and 2003 respectively.⁸⁹ Recall that several studies have found a correlation between breastfeeding and later risk of obesity. Despite this increase in labor force participation, though, the fraction of children ever breastfed has been increasing, as has the fraction breastfed at older ages. Based on data in the NHANES, about 25 percent of children ages 2 to 6 in 1971-1974 were ever breastfed and this number increased slightly to 26 percent in 1976-1980. By the 1988-1994 sample, almost 54 percent were ever breastfed, increasing again by 1999-2002 to 62 percent. Over this same time period, the fraction breastfed for at least three months rose from 55 percent to 74 percent, and those breastfed for at least one year rose from 7 percent to almost 25 percent. Data from the National Survey of Family Growth does not show quite as consistent a pattern. It finds that the percent of babies who were breastfed rises from about 30 percent in 1972-74 to 58 percent in 1993-94. At the same time, the percent breastfed for three months or longer falls from 62 percent to 56 percent, after having risen to 68 percent in 1981-83.⁹⁰ Overall, though, it does not look like trends in breastfeeding are a good candidate for explaining the increase in childhood overweight.

Television is a potentially important contributor to childhood obesity where parental roles may be important. For example, school-age children of working parents may now increasingly spend their afternoon hours unsupervised, which may increase their screen time. More generally, it is parents who make decisions about the number and placement of televisions in a home. In 1970, while 35 percent of homes had more than one television, only 6 percent had three or more

and just 6 percent of sixth graders had one in their bedroom. By 1999, fully 88 percent had more than one, 60 percent had three or more and a whopping 77 percent of sixth graders had a television in their bedroom.⁹¹ Nonetheless, the Hofferth and Sandberg study finds that for children ages 3-12, weekly television viewing dropped by 4 hours between 1981 and 1997.⁹² Reliable and representative data on television viewing is relatively difficult to come by, given the need for detailed diary keeping. Nielsen Media Research is well-known for their measurements of television audiences, though, which are used to set advertising rates.

Based on Nielsen data, overall daily minutes of television watching has climbed in recent decades.⁹³ Figure 7 shows the average daily minutes per person from 1970 to 1999, again superimposing children's obesity rates over the four periods for which NHANES data are available. The overall increase of almost an hour and one half is relatively concentrated in the early 1980s (perhaps due to increasing cable penetration in that time period), the same time period in which the increase in obesity began in earnest. Additionally, viewing appears to be continuing to increase into the current decade, as is obesity. These data, however, are for all television viewers, not children specifically. In their annual reports, Nielsen presents weekly viewing for separate age groups. While these subgroup numbers are fairly noisy and not consistently defined across all years, it appears that in general, children's viewing is between 70 and 90 percent of overall viewing, but seems to have declined over time. For example, in 1982 overall weekly viewing was 28.4 hours while for children age 6-11 it was 24 hours. At the same time, for teens it was about 21 for females and 24 for males. In 1999, overall weekly viewing was still just over 28 hours, but viewing of both younger children and teens had fallen to 19.7 hours.⁹⁴

Children may be substituting other forms of media for television watching, including video games and the internet. According to a 1999 study, children spent 19.3 hours per week watching television, another 2.3 hours playing video games and 2.5 hours in front of the computer, implying just over 1 day (i.e. 24 .1hours) of “screen time” per week.⁹⁵ Note that the television hours in this report are similar to the Nielsen numbers for that year. It may be reasonable to consider the overall Nielsen trend to be an approximation to children’s screen time, with the decrease in children’s television relative to adults resulting from substitution toward video games and instant messaging. Unfortunately, good time series evidence on children’s total screen time is not easily obtainable. Nonetheless, the available time series data is generally supportive of the possibility that changes in screen time may be an important contributor to the increase in childhood obesity.

While parental behavior is important, perhaps one of the biggest influences of parents on children’s overweight and obesity is through genetics. As noted at the beginning, genetics alone cannot explain the increases in obesity we’ve seen in recent decades. Instead, it appears that parents may pass along to their children a susceptibility to overweight in the presence of energy imbalance. Then, changes in the environment that affect energy intake or expenditure trigger weight gain in this susceptible population. It can be difficult to clearly differentiate between nature and nurture in observing the strong correlation between parent and child BMI, though. For example, it is known that parents influence children’s food selection.⁹⁶ Genetics and behavior can thus interact as households with more energy-dense foods available result in both parents and children gaining weight. Similarly, children’s physical activity can be affected by how active their parents are. Again, genes and behavior will interact as households engage in more sedentary behaviors with both parents and children gaining weight.

IV. Conclusion

Obesity has increased over the past three decades for both adults and children in the United States. This paper documents trends in obesity and notes that the increase in obesity seems to have begun between 1980 and 1988. We then summarize the literature on potential causes of children's obesity, and examine whether the things for which there is the strongest evidence of its affecting obesity, seem to have changed over time in ways that are consistent with the time pattern of the obesity epidemic.

Convenience foods and soft drinks are calorie dense and there is some evidence that consuming these items is correlated with obesity in children. Over the critical time period, there is some evidence of increasing availability of these foods to children, through schools, and increased advertising of these products to children. Similarly, there have been changes in the family, namely, more dual career or single-parent-working families, which may have increased demand for food away from home or pre-prepared foods. There is direct evidence of increased consumption of soda pop over the critical period. Although there is evidence that breastfeeding reduces later obesity, breastfeeding seems to have increased over the critical time period (even with more women working when their children are very young), making changes in breastfeeding practices less likely as a candidate for increasing childhood obesity.

On the energy expenditure side, there is a similar mix of evidence. Energy expenditure seems to reduce obesity among children, and there are a host of factors that appear to contribute to reductions in energy expenditure over the critical time period. In particular, children seem to be less likely to walk to school and to be traveling more miles in cars now, than in the early 1970s. This change in children's lives seems to coincide with changes in the built environment

and changes in their parents' work lives that make it more difficult for them to engage in safe, unsupervised (or lightly supervised) physical activity. Finally, the sedentary behavior of watching television seems positively related to obesity, with the time pattern of changes in children's overall screen time looking very consistent with that of the change in children's obesity.

Reviewing the literature, though, one is left with the impression that there has not been one critical factor that has led to increases in children's obesity. Rather, many complementary changes seem to have simultaneously increased children's energy intake and decreased their energy expenditure. The challenge in formulating policies to address children's obesity is not necessarily to determine what one thing changed to create the current epidemic, but rather, what is the most efficacious way to change the environment that affects children's energy balance going forward.

Table 1: Obesity Rates by Country and Year

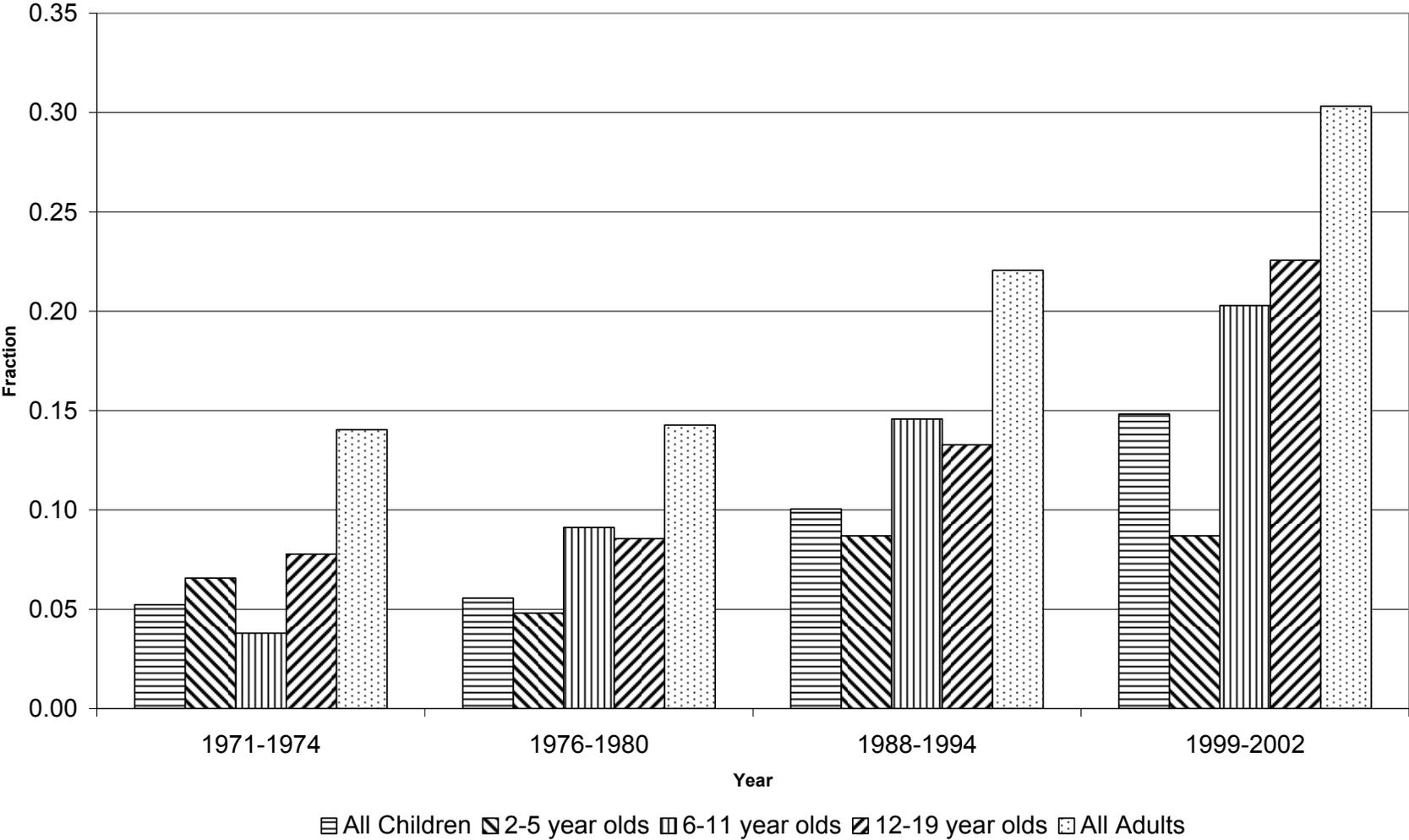
Country	Year(s)	Age(years)	Prevalence of Obesity	
			Men	Women
<i>Europe</i>				
England	1980	16-64	6.0	8
	1987-1987		7	12
	1991		12.7	15
	1994		13.2	16
	1995		15.0	16.5
Finland	1978-1979	20-75	10	10
	1985-1987		12	10
	1991-1993		14	11
Former German Democratic Republic	1985	25-65	13.7	22.2
	1989		13.4	20.6
	1992		20.5	26.8
Netherlands	1987	20-29	6	8.5
	1988		6.3	7.6
	1989		6.2	7.4
	1990		7.4	9.0
	1991		7.5	8.8
	1992		7.5	9.3
	1993		7.1	9.1
	1994		8.8	9.4
	1995		8.4	8.3
Sweden	1980-1981	16-64	4.9	8.7
	1988-1989		5.3	9.1

Table 1 continued: Obesity Rates by Country and Year

Country	Year(s)	Age(years)	Prevalence of Obesity	
			Men	Women
<i>Western Pacific Countries</i>				
Australia	1980	25-64	9.3	8.0
	1983		9.1	10.5
	1989		11.5	13.2
China	1989	20-45	0.29	0.89
	1991		0.36	0.86
Japan	1976	20+	.7	2.8
	1982		.9	2.6
	1987		1.3	2.8
	1993		1.8	2.6
<i>The Americas</i>				
Brazil	1975	25-64	3.1	8.2
	1989		5.9	13.3
Canada	1978	20-70	6.8	9.6
	1981		8.5	9.3
	1988		9.0	9.2
	1986-1990	18-74	15	15

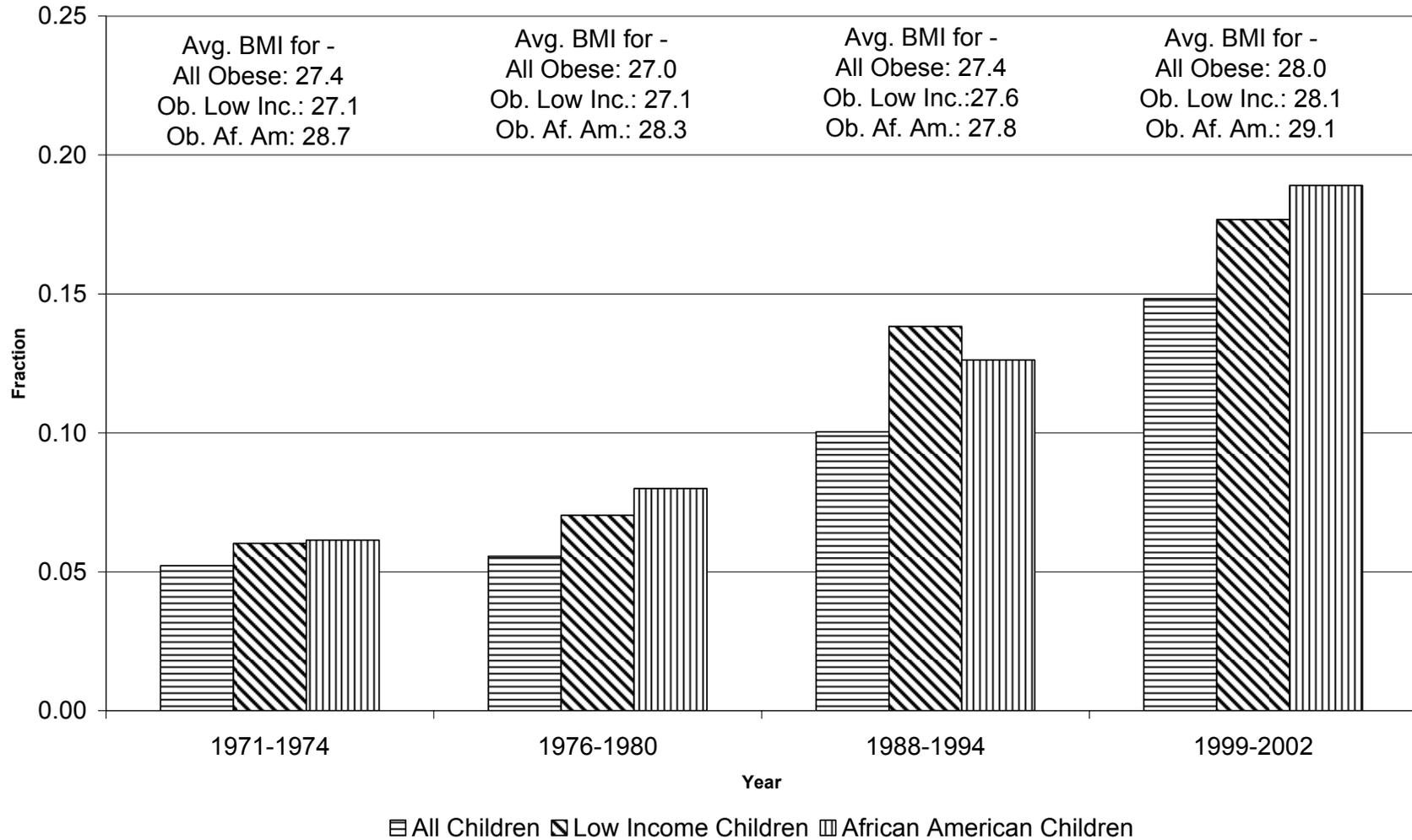
Source: WHO (1998). European countries: Table 3.4, page 25; Western Pacific countries: Table 3.7, page 28; The Americas: Table 3.2, page 22. An individual is categorized as obese if he or she has a Body-Mass-Index of 30 or above.

Figure 1: Fraction of the Population that is Obese



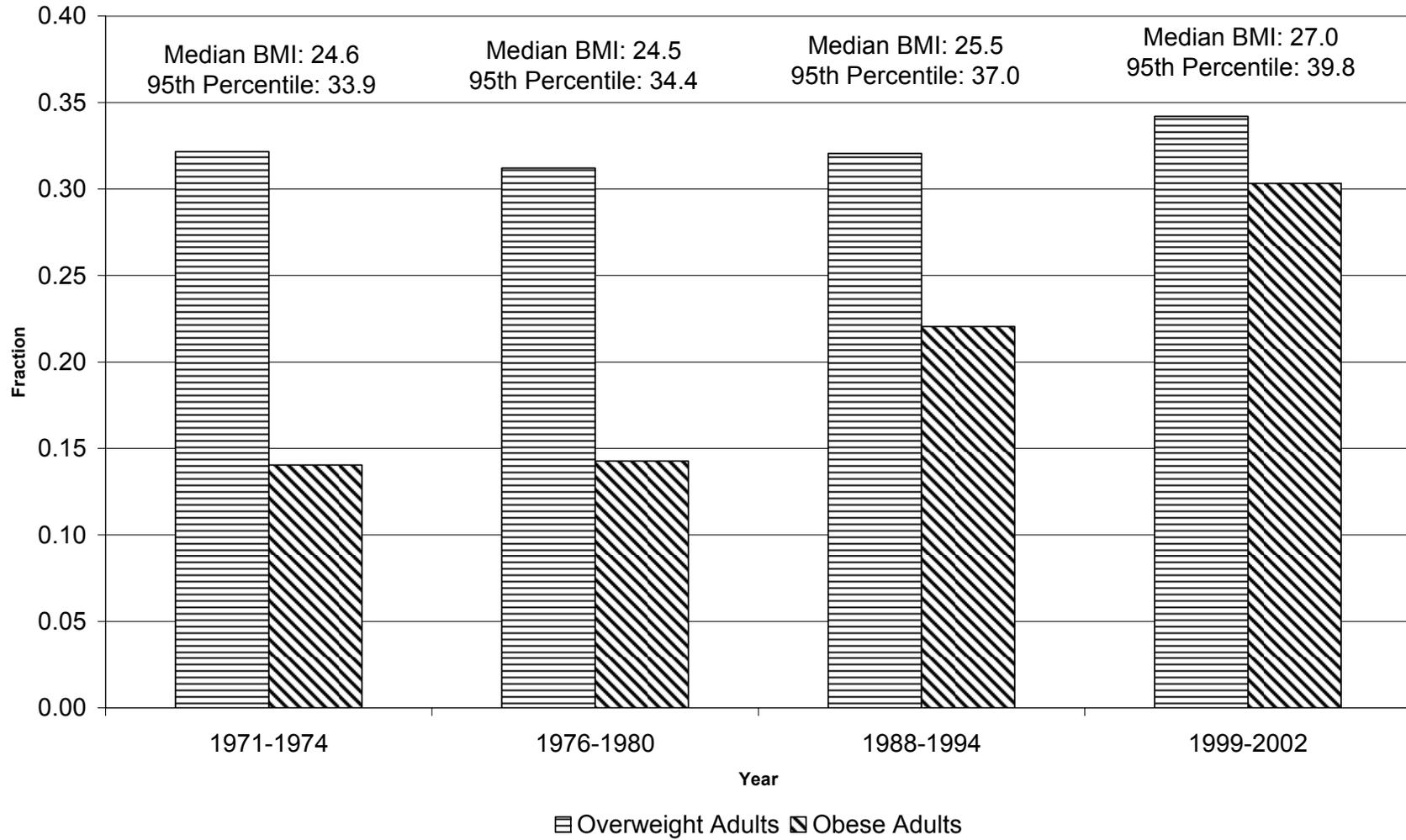
Notes: Authors calculations from National Health and Nutrition Examination Surveys (NHANES).

Figure 2: Fraction Obese and Average BMI among Obese Children, by Group



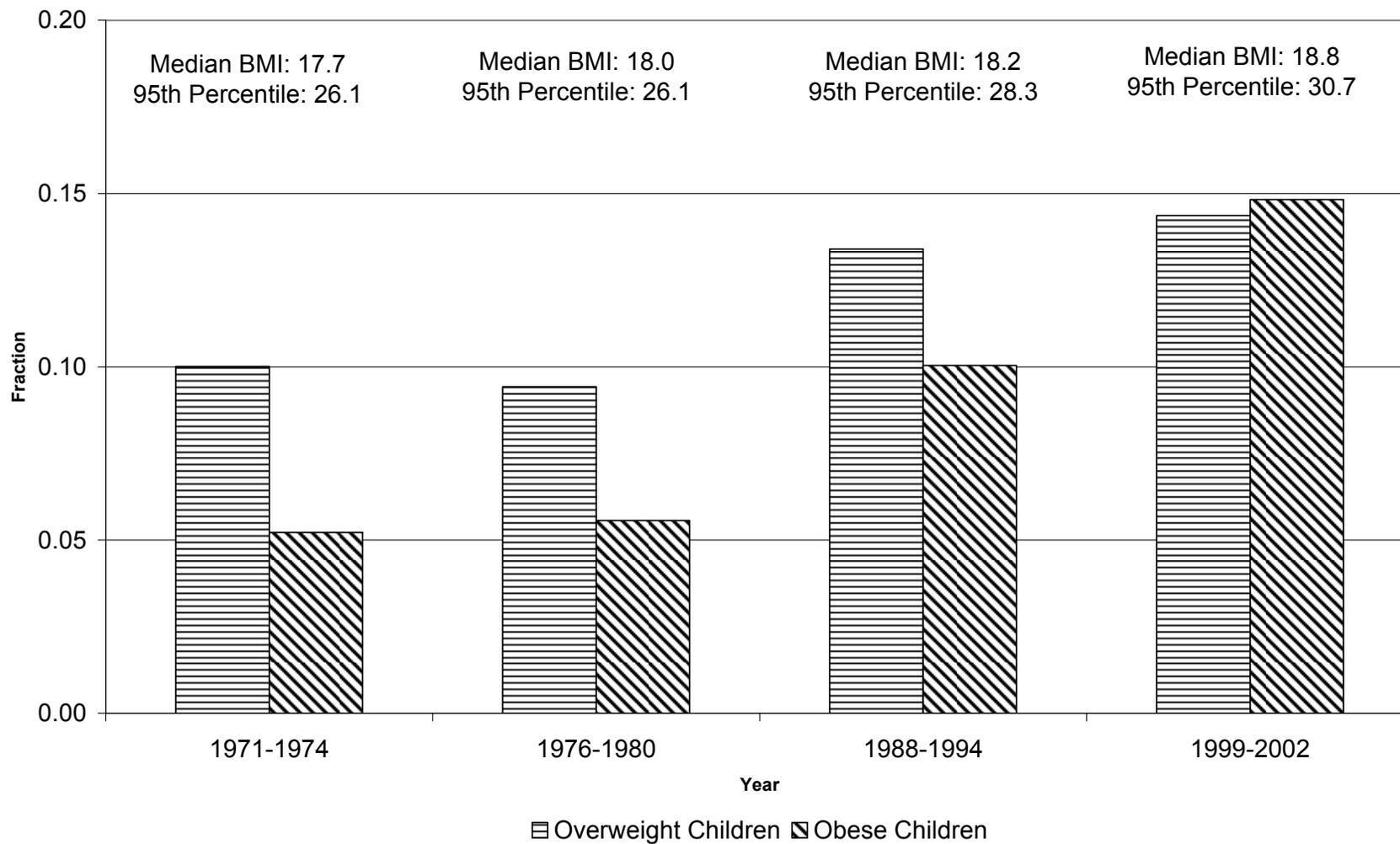
Notes: Authors calculations from National Health and Nutrition Examination Surveys (NHANES).

Figure 3: Fraction of Adults Who Are Overweight or Obese



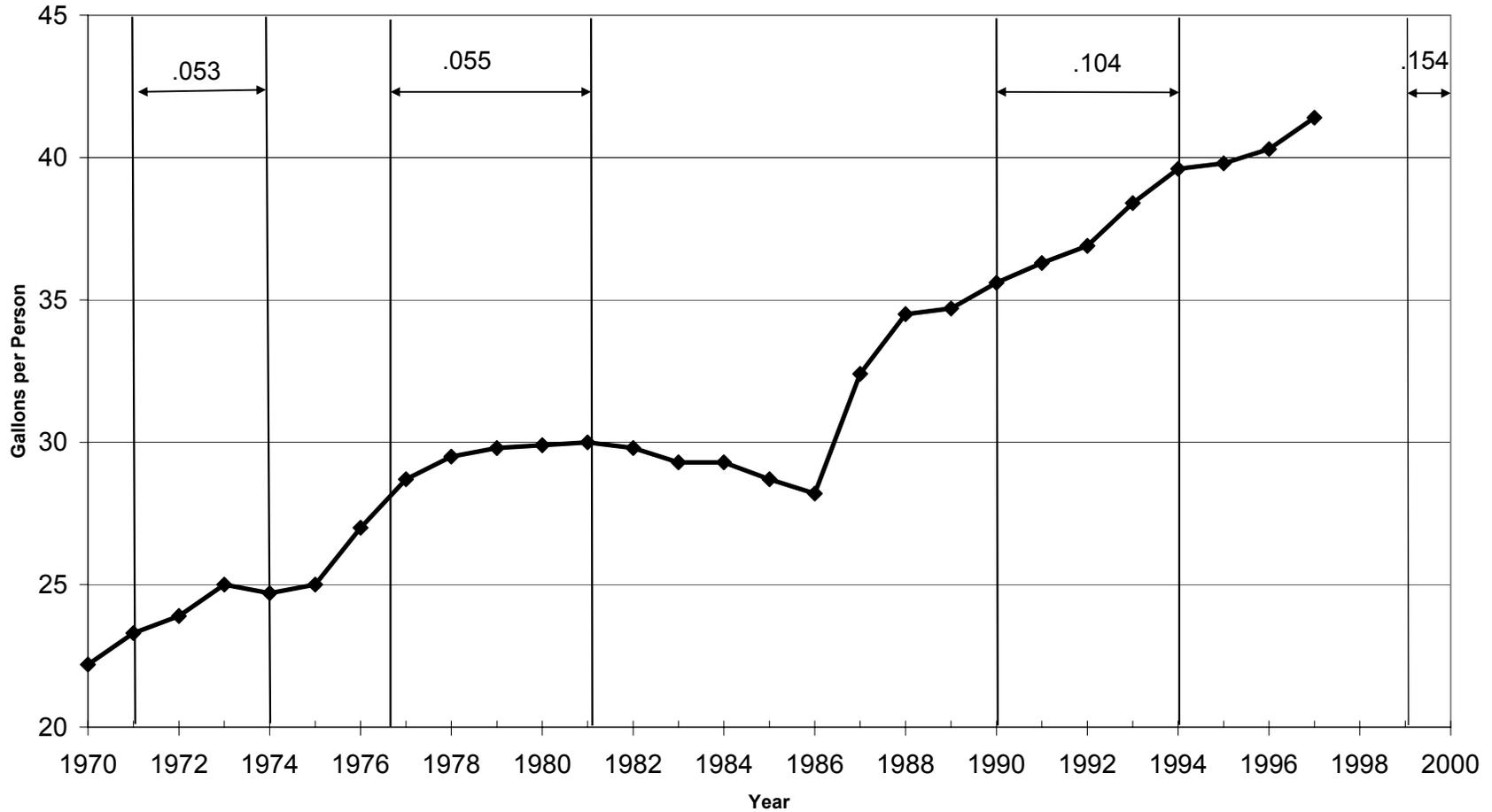
Notes: Authors calculations from National Health and Nutrition Examination Surveys (NHANES).

Figure 4: Fraction of Children Who Are Overweight or Obese



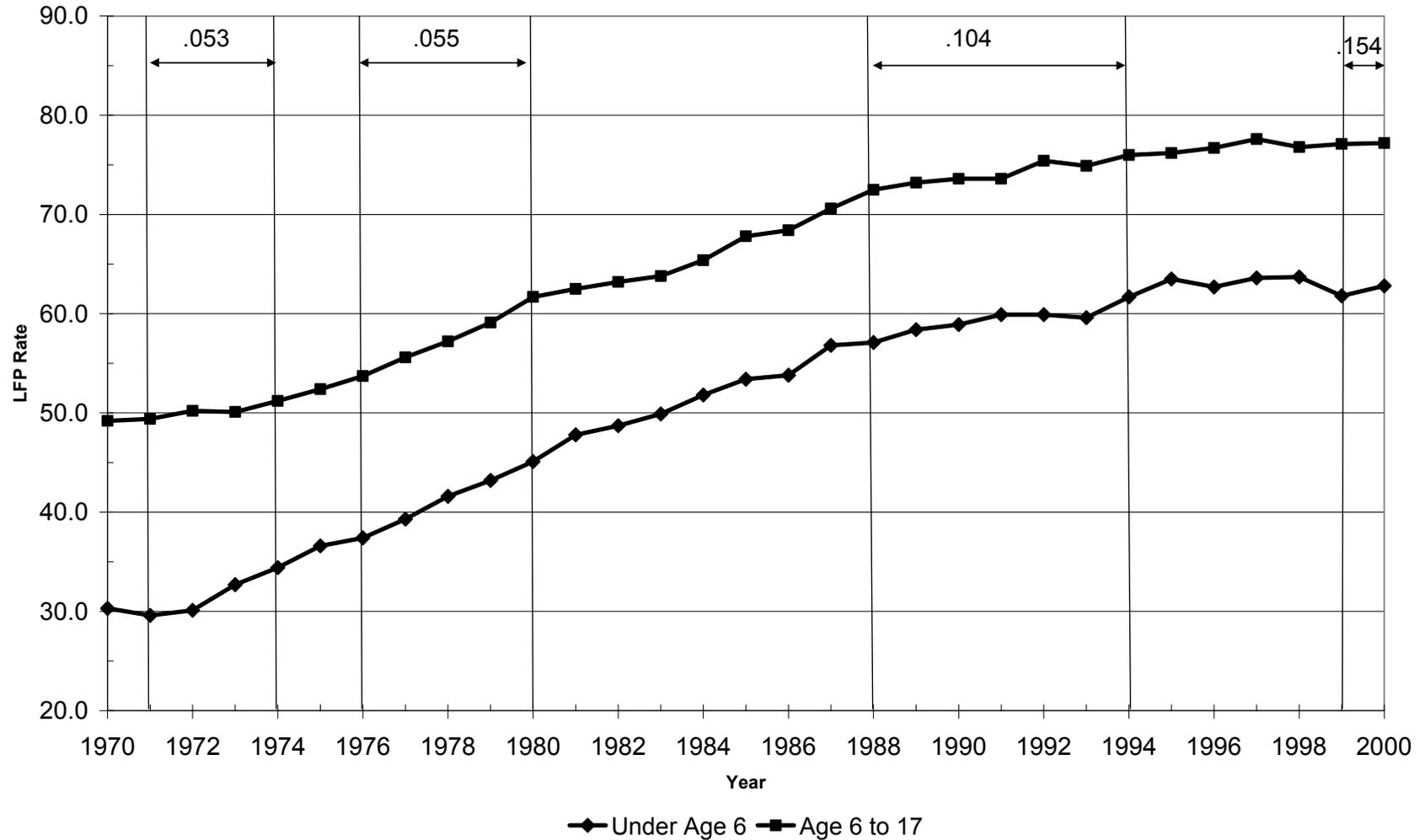
Notes: Authors calculations from National Health and Nutrition Examination Surveys (NHANES).

Figure 5: Annual Regular (Non-Diet) Soft Drink Consumption



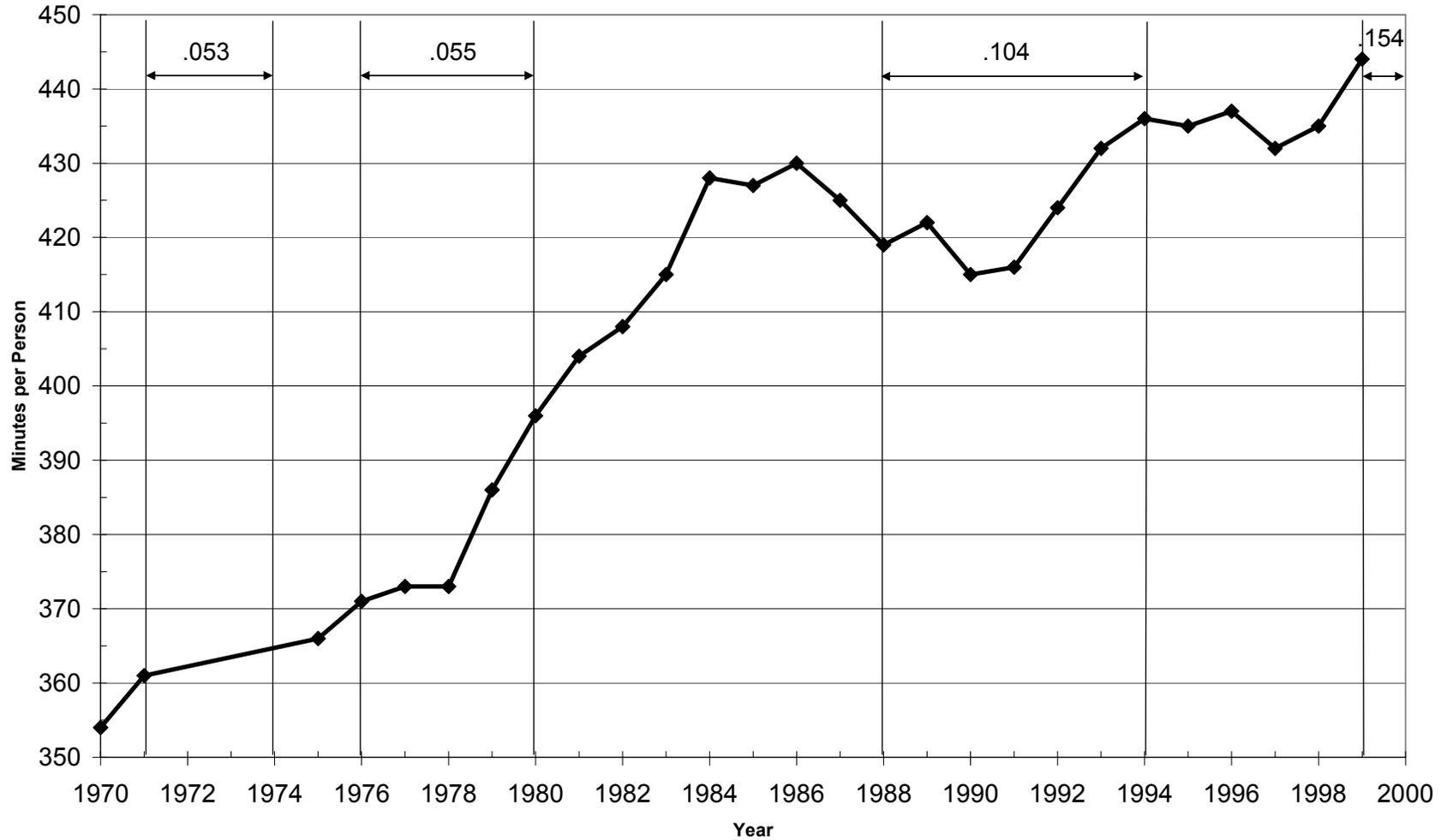
Notes: Vertical lines represent years over which BMI measures are available from NHANES data. The proportions of children overweight in those data are shown. Regular soft drink consumption data for the US overall is from Putnam and Gerrior, 1999.

Figure 6: Labor Force Participation Rate of Married Women with Children



Notes: Vertical lines represent years over which BMI measures are available from NHANES data. The proportions of children overweight in those data are shown. LFP rates are from various years of the *Statistical Abstract of the United States*.

Figure 7: Average Daily Minutes of TV Watching



Notes: Vertical lines represent years over which BMI measures are available from NHANES data. The proportions of children overweight in those data are shown. Daily television minutes are from various years of Nielsen Media's *Report on Television*.

¹ In Imperial measurements, BMI is calculated as (height in inches/(weight in pounds)²)x703.

² National Institutes of Health, “*Clinical Guidelines on the Identification, Evaluation, and Treatment of Overweight and Obesity in Adults: The Evidence Report*,” NIH publication number 98-4083 (September 1998).

³ William H. Dietz and Mary C. Bellizzi, “Introduction: The Use of Body Mass Index to Assess Obesity in Children,” *American Journal of Clinical Nutrition* Vol. 70 (1999): 123S-125S.

⁴ In the medical literature the nomenclature used to describe children’s and adults’ weight is somewhat different. Adults with BMI above the cutoffs described above are either “overweight” or “obese.” Children with BMIs above the 85th percentile are termed “at-risk-of-overweight” and with BMIs above the 95th percentile are termed “overweight.” In order to avoid confusion in comparisons between adults and children, we will term the former group of children “overweight” and the latter group “obese.”

⁵ These percentile cutoffs are available at: http://www.cdc.gov/nchs/about/major/nhanes/growthcharts/clinical_charts.htm#Clin%201

⁶ For more information on the National Health and Nutrition Examination Surveys see the Centers for Disease Control website at <http://www.cdc.gov/nchs/nhanes.htm>.

⁷ World Health Organization, “Obesity: Preventing and Managing the Global Epidemic,” *WHO*, Geneva, 1998.

⁸ These are countries for which the WHO report shows changes in obesity rates over time.

⁹ Note that in the U.S. women have higher obesity rates than men. For 1988-1994, for example, 19.3 percent of men and 24.6 percent of women were obese (20-70 year olds).

¹⁰ Helen Kalies, J. Lenz, and Rüdiger von Kries, “Prevalence of Overweight and Obesity and trends in Body Mass Index in German Pre-School Children 1982-1997,” *International Journal of Obesity* 26 (2002): 1211-1217.

¹¹ Tim J. Lobstein, W. Philip, T. James, and Tim J. Cole, “Increasing levels of Excess Weight among Children in England,” *International Journal of Obesity* 27 (2003):1136-1138.

¹² Juhua Luo and Frank B Hu, “Time Trends of Obesity in Pre-School Children in China from 1989 to 1997,” *International Journal of Obesity* 26 (2002):553-558.

¹³ These are the authors’ calculations based on the National Health and Nutrition Examination Surveys. The data include children 2-19 years old, and adults 20-70 years old. We exclude individuals with a BMI above 50, which drops a small number (less than 100) of individuals in each year. The data are weighted using the examination weight since we use the height and weight that are collected in the medical examination module to define BMI.

¹⁴ There is some concern that obesity rates based on BMI cutoffs may understate obesity among adult women. The cutoff to define obese for both adult women and adult men is 30, but men likely have more lean muscle mass for a given BMI.

¹⁵ Robert C. Whitaker, Jeffrey A. Wright, Margaret S. Pepe, Kristy D. Seidel and William H. Dietz, “Predicting Obesity in Young Adulthood from Childhood and Parental Obesity,” *New England Journal of Medicine* 337 (1997): 869-873.

¹⁶ Obesity rates are also higher among Hispanic children than among white non-Hispanic children. However, it is impossible to consistently define Hispanic across the different NHANES surveys. “Low-income” roughly corresponds to children in families in the lowest quartile of family income. However, each NHANES survey reports family income in categories and these categories do not always correspond to the level of family income that defines the lowest quartile. The income cutoffs used for each year and the mapping between NHANES income categories and income quartiles are available from the authors on request.

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