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# Prevalence and Trends of Severe Obesity among US Children and Adolescents

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## Abstract

**Objective—**To determine the extent to which the 2007 definitions for severe (body mass index ≥99$^{th}$ percentile for age and gender) and morbid (BMI ≥ 40 kg/m$^2$) obesity affects different groups of American children and adolescents and has increased over time.

**Methods—**Analysis of nationally representative data from the National Health and Nutrition Examination Surveys (NHANES) II, III, and 1999–2004;12,384 US children and adolescents ages 2–19 years were included in the analysis. Outcome measures were the proportion of subjects with severe (BMI ≥99$^{th}$ percentile) and morbid (BMI ≥40 kg/m$^2$) obesity, with age, gender, race, and poverty-income ratio (PIR) as key variables.

**Results—**In 1999–2004, 3.8% of children 2–19 yr had a BMI ≥99$^{th}$ percentile, with higher prevalence among boys than girls (4.6% vs. 2.9%; $p<0.001$). Prevalence was highest among Blacks, 5.7% and Mexican Americans, 5.2%, compared with Whites 3.1% ($p< 0.001$). The prevalence differed by PIR category as well (4.3% for those with PIR ≤3 vs. 2.5% for those with PIR > 3; $p = 0.002$). A BMI ≥40 was found in 1.3% of adolescents 12–19 yr, with similar associations with race and poverty. The overall prevalence of BMI ≥99$^{th}$ percentile has increased by more than 300% since NHANES II (1976), and over 70% since NHANES III (1994) in children 2–19 years of age.

**Conclusion—**Rates of severe childhood obesity have tripled in the last 25 years, with significant differences by race, gender and poverty. This places demands on healthcare and community services, especially because the highest rates are among children who are frequently underserved by the health care system.

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**Keywords**

morbid obesity; nutrition surveys; trends; children; adolescents

## INTRODUCTION

The American Academy of Pediatrics currently recommends the use of body mass index (BMI) to screen for obesity in clinical practice. (1,2) The terms Overweight or Obese are used to described a child or adolescent whose BMI is ≥95th percentile for age, based on the current growth curves from the Center for Disease Control and Prevention, with obese being the most currently recognized designation. (3,4) A variety of studies have shown increases in the rates of obesity among children and adolescents, (5–7) with the most recent national data showing a prevalence of 17%. (8) However, there is little data on how common severe or extreme obesity is among US children and adolescents.

An expert committee convened by the American Medical Association, the Centers for Disease Control and Prevention, and the Department of Health and Human Services proposed a new classification of severe childhood obesity in 2007: BMI ≥99th percentile for age and gender. (4) The committee based this recommendation on data from NHANES 1999–2004 that found about 4% of children in the US had a BMI ≥99th percentile. (9) This study applied the 99th percentile cutpoint to a longitudinal cohort, the Bogalusa Heart Study participants, and found that severely obese children had higher rates of obesity and morbid obesity as adults. These severely obese children also had higher prevalence of cardiovascular risk factors and higher levels of adiposity, as measured by serum cholesterol and triglyceride levels, blood pressure, and skinfolds measurements. (9) The classification of severe obesity in children has been recently used in pediatric research, which documented the frequent recognition of this condition in a large academic medical system (8% of 60,711 children and adolescents had a BMI ≥99th percentile, with 76% being correctly identified as such). (10) Childhood obesity has also been shown to be significantly associated with increasing inpatient hospital costs, increasing more than threefold from 1979–1981 to 1997–1999. (11)

Expert panels have made recommendations as when to consider bariatric surgery in obese adolescents. (12,13) Regional and institutional-specific reports have provided some data on the degree of severe childhood obesity, especially in sub-specialty clinics. (14–17) Providers are now considering aggressive forms of therapy because conventional approaches are often ineffective. (18,19) The recommendations have suggested a number of criteria to consider an adolescent for bariatric surgery, which include BMI ≥40 kg/m$^2$ with serious obesity-related co-morbidities or BMI ≥50 kg/m$^2$ with less severe co-morbidities.(12)

Studies have shown higher rates of obesity among racial/ethnic minorities for both adults and children. (5,6,8) Another strong risk factor for obesity appears to be poverty, with studies showing the paradox of those at risk of hunger having some of the highest rates of obesity, independent of ethnic background. (20,21) Adult data from the Behavioral Risk Factor Surveillance System Survey demonstrated a near tripling of class 3 obesity rates in adults (BMI ≥40) from 0.78% in 1990 to 2.2% in 2000, with African-American women and those who did not finish high school disproportionately affected. (22) It is unknown whether these socio-demographic risk factors are associated with severe obesity in childhood. There is a gap in the literature regarding extreme forms of obesity in children and adolescents (BMI ≥99th percentile and ≥40 kg/m$^2$), which is particularly important in light of increasing use of bariatric surgery in adolescent age groups.

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The aim of this report was to examine the change in prevalence of extreme levels of pediatric obesity (severe obesity, BMI ≥99$^{th}$ percentile; morbid obesity, BMI ≥40 kg/m$^2$) between 1976–1980 and 1999–2004; to examine how socio-demographic categories, such as poverty and race/ethnicity, are associated with severe obesity (BMI ≥99$^{th}$ percentile); and to determine whether severe obesity carries higher cardiovascular risk factors than simple obesity (BMI 95–98.9$^{th}$ percentile).

# METHODS

## The National Health and Nutrition Examination Survey

In NHANES, a representative sample of the non-institutionalized, US population is selected using a complex multistage probability sampling design. This study examined data from NHANES conducted at 5 time periods: 1976–1980, 1988–1994, (23) 1999–2000, (24) 2001–2002, (25) and 2003–2004. (26) After being interviewed in their homes, subjects were invited to be examined in a mobile examination center. Height and weight measurements were obtained using standardized techniques and equipment. Weight was measured on a Toledo self-zeroing weight scale, and height was measured with a stadiometer to the nearest millimeter. Identical procedures for conducting anthropometry were used throughout NHANES surveys to ensure comparability of anthropometric measures over time. Quality control procedures were observed to minimize body measurement errors due to body positioning or in reading and recording the measurements. Other variables included in our analyses were gender, age, race/ethnicity (i.e., white, black, Mexican American, and other, representing smaller groups including Amercian Indian, Alaska Native, Native Hawaiian, Guamanian, Somoan, Asian Indian, Chinese, Filipino, Japanese, Korean, Vietnamese, Other Asian, and Other Race) and poverty income ratio. Poverty income ratio (PIR) is the ratio of the midpoint of observed family income category to the official poverty threshold (scaled to family size). PIR accounts for family size and is independent of inflation, as the poverty threshold is based on annual US Census Bureau data. Poverty income ratio (PIR) < 1 identifies individuals who are below the federal poverty level. Higher levels of poverty-income-ratio (PIR 1–3, and PIR >3) indicate relatively higher socio-economic status, which have been shown to be protective factors for adult obesity. (27,28)

## Obesity Categories

Among children and adolescents, obesity was defined at or above the 95$^{th}$ percentile of the age and gender-specific BMI growth chart from the Center for Disease Control and Prevention (CDC). (29) Obese subjects were also categorized into 3 groups of increasing severity: BMI 95$^{th}$ to 96.9$^{th}$ percentile, BMI 97$^{th}$ to 98.9$^{th}$ percentile, and BMI ≥99$^{th}$ percentile. The BMI ≥97$^{th}$ percentile was included in these analyses because there are alternate versions of the 2000 CDC growth curves with the 97$^{th}$ percentile lines and this cutpoint could therefore be tracked clinically. (7) The cut-off of BMI ≥99$^{th}$ percentile was applied from the recent AMA/CDC/DHHS Expert Committee Recommendations on the Assessment, Prevention, and Treatment of Child and Adolescent Overweight and Obesity. (4) A sub- analysis was conducted on adolescents, 12–19 years of age, to describe those with a BMI ≥40 kg/m$^2$.

## Statistical Analysis

Data were analyzed using SAS version 9.1 (Cary, NC: SAS Institute Inc; 2002) and SUDAAN version 9.0 (Research Triangle Park, NC; Research Triangle Institute, 2004). Pregnant females were excluded from the analyses. All analyses used sample weights to account for differential probabilities of non-response, non-coverage, and of selection into the sample. Standard errors were estimated using Taylor series linearization. Bivariate (unadjusted) analyses were conducted to determine associations with different levels of obesity. Chi-square tests were used to test hypotheses at the overall significance level of p<0.05. The Bonferroni method was used

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to adjust for multiple comparisons across racial/ethnic groups. The Cochran-Armitage Trend Test was used to test for trends. Our *a priori* hypothesis was that rates of severe obesity (BMI ≥99$^{th}$ percentile and BMI ≥40) would differ by race/ethnic groups and by poverty-income ratio. We also hypothesized the trends in cross sectional prevalence rates would also differ by race/ethnic groups and by PIR.

## RESULTS

### Population Characteristics and Obesity, NHANES 1999–2004

The study population included 12,384 children, representing approximately 71 million US children ages 2–19 years. There were 123 pregnant females excluded from the analysis. Nearly 16% of children 2–19 years were obese (BMI ≥95$^{th}$ percentile) in 1999–2004, with 10.8% having a BMI ≥97$^{th}$ percentile and nearly 4% having a BMI ≥99$^{th}$ percentile. Based on this data, the estimated number of children in the US with a BMI ≥99$^{th}$ percentile is 2.7 million. Detailed demographic data including gender, age group, race/ethnicity, and poverty-income ratio are shown for children across all BMI categories (Table 1). In both groups (BMI 97$^{th}$ – 98.9$^{th}$, and ≥99$^{th}$ percentile), there were significant differences by race/ethnicity, with minority groups (Black, Mexican-American) having higher prevalence of severe obesity than Whites ($p<0.001$). There were also differences by poverty-income ratio, with PIR > 3 (most affluent) having the lowest prevalence. In BMI 97$^{th}$ – 98.9$^{th}$ percentile, there were significant differences by age groups, with the highest percentage found in older age groups (12–19 years). There were significantly more boys with a BMI ≥99$^{th}$ percentile than girls ($p=0.001$).

### Absolute BMI values as cutpoint for severe obesity

An estimated 418,000 U.S. adolescents, ages 12–19 years, had a BMI ≥40 kg/m$^2$ based on a prevalence of 1.3% by 1999–2004 data. Detailed demographic data are shown (Table 2). Again, minority populations had significantly higher prevalence, with 3.4% of Black teens having a BMI ≥40 kg/m$^2$ ($p<0.001$), as well as those below the poverty level compared to the highest PIR category ($p=0.002$).

### Severe Obesity Trends: NHANES II (1976–1980), NHANES III (1988–1994), NHANES 1999–2004

When compared to children 2–19 years from NHANES II, the overall prevalence rate of BMI ≥99$^{th}$ percentile increased by > 300% from 0.8% in 1976–1980 to 3.8% in 1999–2004 ($p<0.001$), and by 72% since NHANES III (1988–1994) ($p<0.001$) (Appendix Table 1); changes by age groups (Figure 1) and by gender (Figure 2) are shown. Among Whites, changes were minimal, yet significant changes were seen in Blacks and Mexican-Americans (Figure 3). Among those below the poverty threshold (PIR < 1), prevalence rates increased from 0.7% (NHANES II) to 3% (NHANES III) to 4.3% (NHANES 1999–2004) ($p<0.001$, test for trend). Prevalence rates were related to poverty level, (PIR 1–3), with rates increasing from 1.1% to 1.9% to 4.3% ($p<0.001$, for trend). There were no significant race/ethnicity-poverty interactions found on further analysis.

### Cardiovascular risk factors

When compared to adolescents with BMI in the 95th–96.9$^{th}$ percentile, youth with a BMI ≥99$^{th}$ percentile had significantly different mean levels of systolic and diastolic blood pressure, HDL cholesterol, and insulin. (Table 3) Additionally, liver function tests (AST, ALT, and GGT) and waist circumference were higher in those with a BMI ≥99$^{th}$ percentile. Fasting total and LDL cholesterol, triglycerides and glucose did not differ between these groups. When the Adult Treatment Panel III (of the National Cholesterol Education Program) criteria for metabolic syndrome (with glucose ≥110 mg/dl and glucose ≥100 mg/dl) were applied, a third of the children with a BMI ≥99$^{th}$ percentile (32 and 33%, respectively) were classified as having the metabolic syndrome, significantly more than the 13–17% in the 95$^{th}$–97$^{th}$ percentile range.

## DISCUSSION

This analysis found that among the almost 4% (2.7 million) of U.S. children who have a BMI ≥99th percentile for age/gender (1999–2004), there were significant differences by race, gender and poverty. The higher prevalence among Black and Mexican-American youth and among youth of lower income reflects the associations between these groups and the larger group of children with BMI ≥95$^{th}$ percentile. Overall, prevalence of BMI ≥99th percentile has increased by over 300% since 1976, and by over 70% since 1994. This analysis also demonstrated a high prevalence of teens with BMI ≥40 kg/m$^2$ (>400,000). This level of severe adiposity is part of the initial criteria for considering bariatric surgery in adolescents. (12) Given the immediate and future health risk and costs associated with this growing prevalence, these groups need more careful attention.

Higher socio-economic positions seem to protect against morbid and severe obesity. Explanations for this association may include the easy availability and low cost of energy-dense snacks in poor, inner-city neighborhoods. (30) In contrast, fresh fruits and vegetables are often not available, and adequate amounts are expensive. (31) Recent reports confirm the seemingly paradoxical connection of poverty, food insecurity, and obesity. (21) Even more surprising is that the risk may carry through to the morbidly and severely obese. The effect of poverty on levels of physical activity is unknown. One report showed an increased risk of obesity in 7 year olds when they perceived their neighborhood as unsafe (32), whereas others have shown an inverse effect of income on sedentary activity. (33) All of these findings implicate the environment as an important factor, but one over which the child has little control. Most worrisome is that vulnerable populations are experiencing the worst increase in severe obesity, as rates in Whites and the affluent have plateaued.

Many cardiovascular risk factors, such as higher waist circumference, insulin resistance (evidenced by elevated fasting insulin), blood pressure, and lower HDL cholesterol, were associated with BMI ≥99$^{th}$ percentile in this study. The application of adult criteria of the metabolic syndrome to this population showed upwards of a third met the criteria. The higher rates of elevated ALT among severely obese youth supports the recent Expert Committee Recommendations for pediatric primary care providers to routinely assess liver transaminases as a screen for non-alcoholic fatty liver disease. These findings demonstrate the significant health risks facing this morbidly obese group.

Anthropometric cutpoints for severe obesity in youth are sought in order to guide use of aggressive interventions, like bariatric surgery, that may be more effective but have higher risk and costs than behavior-based treatment. (34) Recent criteria for identification of adolescents for bariatric surgery propose absolute BMI ≥40 with a co-morbidity (12) but this cutpoint may not capture those younger adolescents who have dangerous levels of obesity despite having a BMI < 40 kg/m2. BMI ≥99$^{th}$ percentile is a cutpoint that identifies greater risk of later obesity and cardiovascular complications compared with obese children with lower BMI percentile. (9) In addition, this cutpoint identifies the same deviation from median BMI across ages and genders. In contrast, BMI of 40 kg/m$^2$ defines a higher deviation from median BMI in younger adolescents compared with older adolescents and in boys compared with girls. Greater than 99$^{th}$ percentile, because it accounts for age and gender, can be applied to pre-adolescents and even preschool children. Although surgery and medication are not appropriate for these younger children, increased resources to support intensive behavior-based programs may lead to an effect that justifies greater cost. Classification of severe obesity allows assessment of the health burden and the healthcare system needs of these children. Treatment of



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hypercholesterolemia and diabetes is reimbursable by insurers, yet these diseases are quite rare across pediatric populations (0.8% of US teens have hypercholesterolemia requiring pharmacotherapy (35), and only 0.18% have diabetes (36)). The higher prevalence of severe childhood obesity among generally disadvantaged sectors of society heightens the need for greater research, prevention, and treatment efforts, as well as a coordinated approach to public health efforts.

Limitations to our analysis include small sample sizes among some minority groups with a BMI ≥40 kg/$m^2$. As with other analyses using NHANES, results with small sample sizes may have relative large standard errors (> 30%) and could therefore be statistically unstable and should be interpreted with caution. The tables identify these comparisons, most common in the NHANES II cohort. The data are cross-sectional, and causality cannot be inferred from any of the associations found. Poverty income ratio is an imperfect marker of SES, with other factors such as parent education levels, being superior measures of socio-economic position. (37)

## CONCLUSION

There are 2.7 million children with a BMI that puts them at significantly increased risk of multiple medical and psychological co-morbidities, and it is likely that their obesity will continue into adulthood. Over 400,000 adolescents might meet criteria for bariatric surgery. These groups seem likely to increase in number. With prevalence rates high and climbing, the Expert Committee Recommendations have endorsed the category of severe obesity as part of the clinical criteria to direct medical screening and to initiate referral for care. However, specialized clinical and behavioral services appropriate for severely obese children may be unavailable or may not be covered by medical insurance. (38) At the same time, primary care pediatricians face many barriers to clinical screening and management including lack of training, tools, referral resources and re-imbursement. (39) This mismatch of need and services is greatest among poor and among children in minority groups, who have both the highest severe obesity rates and the greatest difficulty accessing healthcare. No simple answers exist, but the best chance for success is immediate attention to this problem in both primary and tertiary care systems, supported by collaboration and mobilization of health care insurers and regional systems, and by broad social and community support for healthier lifestyles for children.

## Acknowledgments

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## References

1. Committee on Nutrition. Prevention of Pediatric Overweight and Obesity. Pediatrics 2003;112:424–430. [PubMed: 12897303]
2. Barlow SE, Dietz WH. Obesity evaluation and treatment: Expert Committee recommendations. The Maternal and Child Health Bureau, Health Resources and Services Administration and the Department of Health and Human Services. Pediatrics 1998;102:E29. [PubMed: 9724677]
3. Ogden CL, Troiano RP, Briefel RR, Kuczmarski RJ, Flegal KM, Johnson CL. Prevalence of overweight among preschool children in the United States, 1971 through 1994. Pediatrics 1997;99:E1. [PubMed: 9099776]
4. Barlow SE. the Expert Committee. Expert Committee Recommendations Regarding the Prevention, Assessment, and Treatment of Child and Adolescent Overweight and Obesity: Summary Report. Pediatrics 2007;120:S164–S192. [PubMed: 18055651]

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5. Hedley A, Ogden C, Johnson C, Carroll M, Curtin L, Flegal K. Prevalence of Overweight and Obesity Among US Children, Adolescents, and Adults, 1999–2002. JAMA 2004;291:2847–2850. [PubMed: 15199035]
6. Ogden CL, Flegal KM, Carroll MD, Johnson CL. Prevalence and Trends in Overweight Among US Children and Adolescents, 1999–2000. JAMA 2002;288:1728–1732. [PubMed: 12365956]
7. Ogden CL, Kuczmarski RJ, Flegal KM, et al. Centers for Disease Control and Prevention 2000 growth charts for the United States: improvements to the 1977 National Center for Health Statistics version. Pediatrics 2002;109:45–60. [PubMed: 11773541]
8. Ogden CL, Carroll MD, Curtin LR, McDowell MA, Tabak CJ, Flegal KM. Prevalence of Overweight and Obesity in the United States, 1999–2004. JAMA 2006;295:1549–1555. [PubMed: 16595758]
9. Freedman DS, Mei Z, Srinivasan SR, Berenson GS, Dietz WH. Cardiovascular risk factors and excess adiposity among overweight children and adolescents: the Bogalusa Heart Study. J Pediatr 2007;150:12–17.e2. [PubMed: 17188605]
10. Benson L, Baer HJ, Kaelber DC. Trends in the Diagnosis of Overweight and Obesity in Children and Adolescents: 1999–2007. Pediatrics 2009;123:e153–158. [PubMed: 19117837]
11. Wang G, Dietz WH. Economic Burden of Obesity in Youths Aged 6 to 17 Years: 1979–1999. Pediatrics 2002;109:e81. [PubMed: 11986487]
12. Inge TH, Krebs NF, Garcia VF, et al. Bariatric Surgery for Severely Overweight Adolescents: Concerns and Recommendations. Pediatrics 2004;114:217–223. [PubMed: 15231931]
13. Inge TH, Garcia VF, Daniels SR, et al. A multidisciplinary approach to the adolescent bariatric surgical patient. J Pediatr Surg 2004;39:442–447. [PubMed: 15017567]
14. Quattrin T, Liu E, Shaw N, Shine B, Chiang E. Obese Children Who Are Referred to the Pediatric Endocrinologist: Characteristics and Outcome. Pediatrics 2005;115:348–351. [PubMed: 15687443]
15. Miller LA, Grunwald GK, Johnson SL, Krebs NF. Disease severity at time of referral for pediatric failure to thrive and obesity: time for a paradigm shift? J Pediatr 2002;141:121–124. [PubMed: 12091862]
16. Riley MR, Bass NM, Rosenthal P, Merriman RB. Underdiagnosis of Pediatric Obesity and Underscreening for Fatty Liver Disease and Metabolic Syndrome by Pediatricians and Pediatric Subspecialists. J Pediatr 2005;147:839–842. [PubMed: 16356443]
17. Weiss R, Dziura J, Burgert T, et al. Obesity and the Metabolic Syndrome in Children and Adolescents. N Engl J Med 2004;350:2362–2374. [PubMed: 15175438]
18. Kirschenbaum DS, Germann JN, Rich BH. Treatment of morbid obesity in low-income adolescents: effects of parental self-monitoring. Obes Res 2005;13:1527–1529. [PubMed: 16222054]
19. Rolland-Cachera MF, Thibault H, Souberbielle JC, et al. Massive obesity in adolescents: dietary interventions and behaviors associated with weight regain at 2 years follow-up. Int J Obes 2004;28:514–519.
20. Drewnowski A, Specter SE. Poverty and Obesity: the role of energy density and energy costs. Am J Clin Nutr 2004;79:6–16. [PubMed: 14684391]
21. Casey PH, Simpson PM, Gossett JM, et al. The association of child and household food insecurity with childhood overweight status. Pediatrics 2006;118:e1406–13. [PubMed: 17079542]
22. Freedman DS, Khan LK, Serdula MK, Galuska DA, Dietz WH. Trends and correlates of class 3 obesity in the United States from 1990 through 2000. JAMA 2002;288:1758–61. [PubMed: 12365960]
23. Centers for Disease Control and Prevention. The Third National Health and Nutrition Examination Survey (NHANES III 1988–94); Reference Manuals and Reports [CD-ROM]; Bethesda, MD: National Center for Health Statistics; 2005.
24. Centers for Disease Control and Prevention. NHANES 1999–2000 public data release file documentation. [Accessed November 3 2006]. Available at: www.cdc.gov/nchs/about/major/nhanes/nhanes99-00.htm
25. Centers for Disease Control and Prevention. NHANES 2001–2002 public data release file documentation. [Accessed November 3 2006]. Available at: www.cdc.gov/nchs/about/major/nhanes/nhanes01-02.htm

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26. Centers for Disease Control and Prevention. NHANES 2003–2004 public data release file documentation. [Accessed November 3 2006]. Available at: www.cdc.gov/nchs/about/major/nhanes/nhanes2003-2004/nhanes03_04.htm
27. McLaren L. Socioeconomic Status and Obesity. Epidemiol Rev 2007;29:29–48. [PubMed: 17478442]
28. Haas JS, Lee LB, Kaplan CP, Sonneborn D, Phillips KA, Liang SY. The association of race, socioeconomic status, and health insurance status with the prevalence of overweight status among children and adolescents. Am J Public Health 2003;93:2105–2110. [PubMed: 14652342]
29. CDC National Center for Health Statistics. 2000 CDC Growth Charts: United States. Percentile Data Files with LMS Values. [Accessed November 3, 2006]. Available at: www.cdc.gov/nchs/data/nhanes/growthcharts/bmiage.txt
30. Drewnowski A, Darmon N. Food Choices and Diet Costs: an Economic Analysis. J Nutr 2005;135:900–904. [PubMed: 15795456]
31. Cassady D, Jetter KM, Culp J. Is price a barrier to eating more fruits and vegetables for low-income families? J Am Diet Assoc 2007;107:1909–15. [PubMed: 17964310]
32. Lumeng JC, Appugliese D, Cabral HJ, Bradley R, Zuckerman B. Neighborhood safety and overweight status in children. Arch of Pediatr Adol Med 2006;160:25–31.
33. Burdette HL, Whitaker RC. A national study of neighborhood safety, outdoor play, television viewing, and obesity in preschool children. Pediatrics 2005;116:657–62. [PubMed: 16140705]
34. Tsai WS, Inge TH, Burd RS. Bariatric Surgery in Adolescents: Recent National Trends in Use and In-Hospital Outcome. Arch Pediatr Adol Med 2007;161:217–221.
35. Ford ES, Li C, Zhao G, Mokdad AH. Concentrations of Low-Density Lipoprotein Cholesterol and Total Cholesterol Among Children and Adolescents in the United States. Circulation 2009;119:1108–1115. [PubMed: 19221218]
36. SEARCH for Diabetes in Youth Study Group. The Burden of Diabetes Mellitus Among US Youth: Prevalence Estimates From the SEARCH for Diabetes in Youth Study. Pediatrics 2006;118:1510–1518. [PubMed: 17015542]
37. Galobardes B, Shaw M, Lawlor DA, Lynch JW, Davey Smith G. Indicators of socioeconomic position (part 1). J of Epidemiol Community Health 2006;60:7–12. [PubMed: 16361448]
38. Tershakovec AM, Watson MH, Wenner WJ, Marx AL. Insurance reimbursement for the treatment of obesity in children. J Pediatr 1999;134:573–8. [PubMed: 10228292]
39. Story MT, Neumark-Stzainer DR, Sherwood NE, et al. Management of child and adolescent obesity: attitudes, barriers, skills, and training needs among health care professionals. Pediatrics 2002;110:210–214. [PubMed: 12093997]

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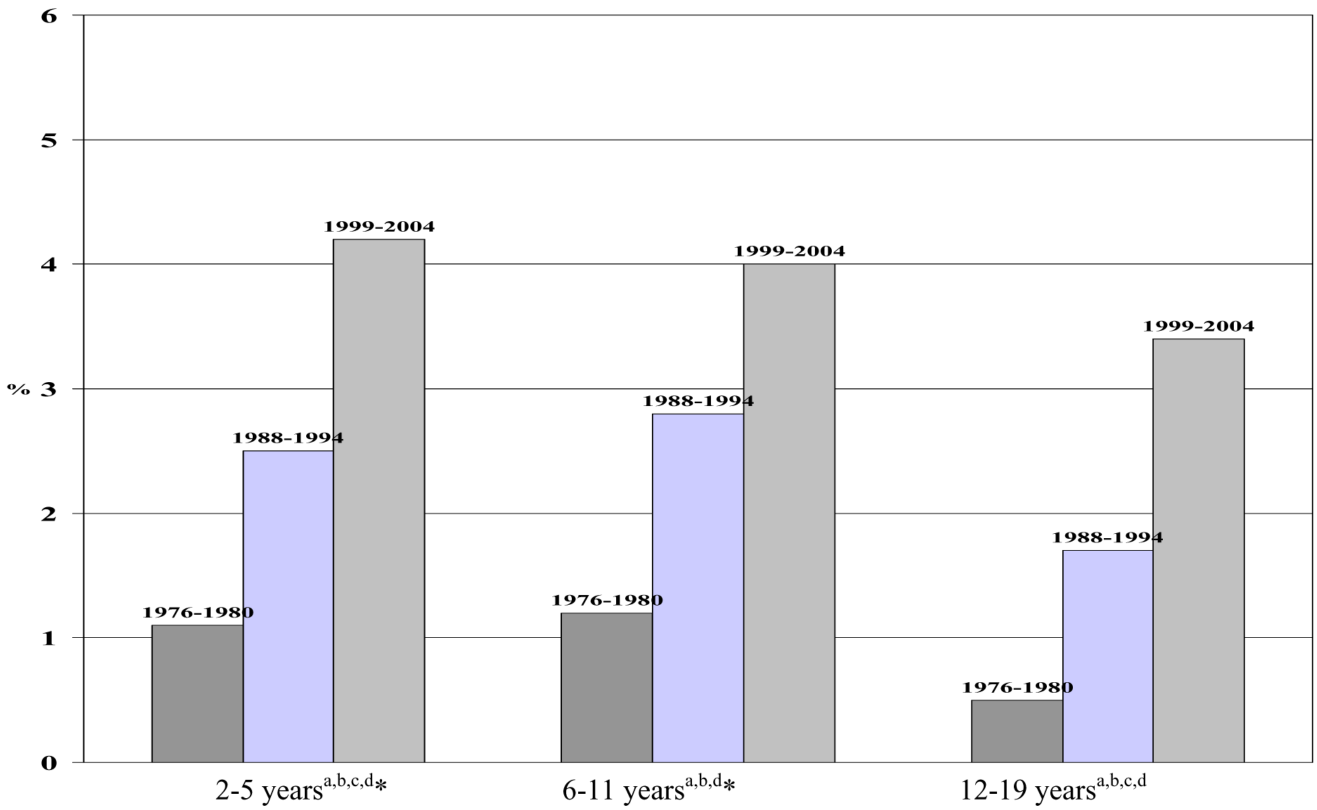


**Figure 1.**
Prevalence of BMI ≥99th Percentile Among U.S. Children Ages 2–19 Years, NHANES II (1976–1980), NHANES III (1988–1994) and NHANES 1999–2004, by age groupings
[a] $p<0.001$ for trends from NHANES II to NHANES III to NHANES 1999–2004
[b] $p<0.001$ comparing NHANES II to NHANES 1999–2004
[c] $p<0.05$ comparing NHANES III to NHANES 1999–2004
[d] $p \leq 0.01$ comparing NHANES II to NHANES III
* Estimates for NHANES II based on sample size <30 or relative standard error >30% and may be unreliable

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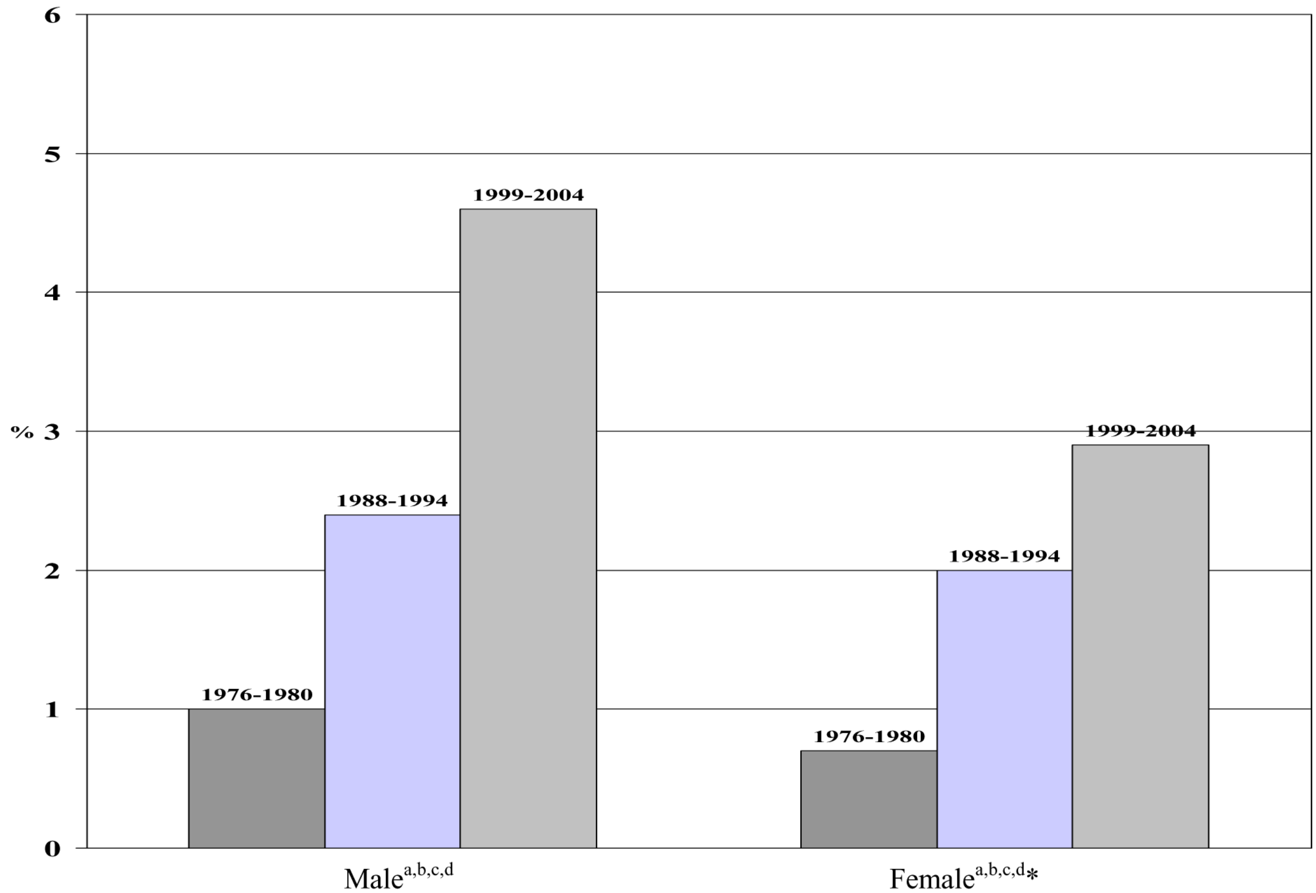


**Figure 2.**
Prevalence of BMI ≥99th Percentile Among U.S. Children Ages 2–19 Years, NHANES II (1976–1980), NHANES III (1998-1994) and NHANES 1999–2004, by gender
[a] p<0.001 for trends from NHANES II to NHANES III to NHANES 1999–2004
[b] p<0.001 comparing NHANES II to NHANES 1999–2004
[c] p=0.04 comparing NHANES III to NHANES 1999–2004
[d] p ≤ 0.003 comparing NHANES II to NHANES III
* Estimates for NHANES II females based on sample size <30 or relative standard error >30% and may be unreliable

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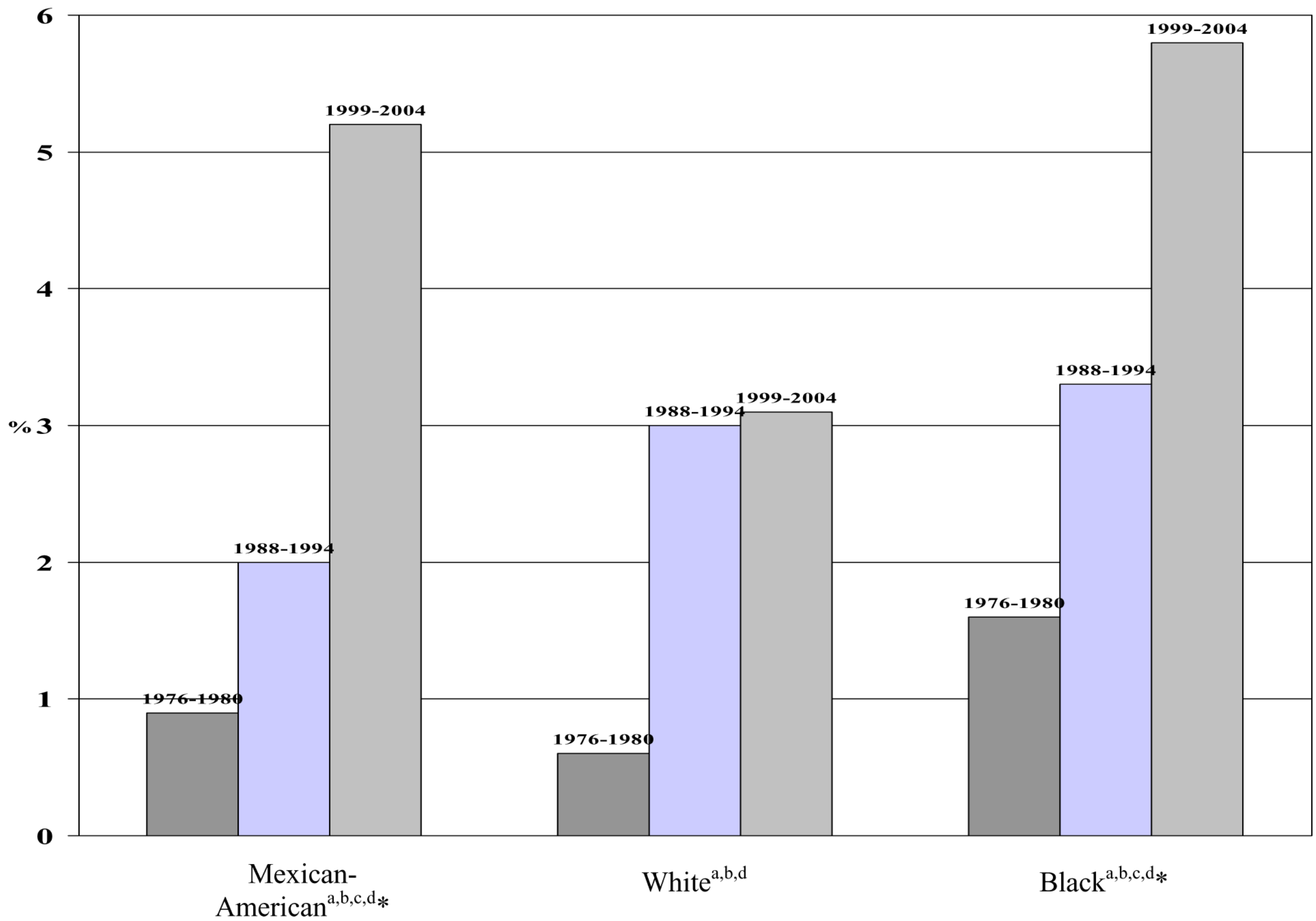


**Figure 3.**

Prevalence of BMI ≥99th Percentile Among U.S. Children Ages 2–19 Years, NHANES II (1976–1980), NHANES III (1988–1994) and NHANES 1999–2004, by race/ethnic groups

[a] $p<0.001$ for trends from NHANES II to NHANES III to NHANES 1999–2004

[b] $p<0.001$ comparing NHANES II to NHANES 1999–2004

[c] $p<0.001$ comparing NHANES III to NHANES 1999–2004

[d] $p \leq 0.03$ comparing NHANES II to NHANES III

* Estimates for NHANES II Mexican-American and Black based on sample size <30 or relative standard error >30% and may be unreliable

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**Table 1**

Prevalence of Obesity Among 12,384 U.S. Children Ages 2–19 Years, NHANES 1999–2004 (no exclusion criteria)

| | n | % <95th | % 95–96.9th | % 97–98.9th | % ≥ 99th | p-value |
|---|---|---|---|---|---|---|
| **Total and Overall Percentage** | **12,384** | **84.3% (n=10,162) (59.3 million)** | **4.9% (n=625) (3.4 million)** | **7.0% (n=1,021) (4.9 million)** | **3.8% (n=576) (2.7 million)** | |
| Sex | | | | | | 0.001 |
| Male | 6,204 | 83.6 | 4.9 | 6.9 | 4.6 | |
| Female | 6,180 | 85.0 | 4.9 | 7.2 | 2.9 | |
| Age, years | | | | | | <0.001 |
| 2–5 | 2,340 | 88.6 | 3.4 | 3.8 | 4.2 | |
| 6–11 | 3,195 | 83.2 | 5.8 | 7.0 | 4.0 | |
| 12–19 | 6,849 | 83.3 | 4.8 | 8.4 | 3.4 | |
| Race/ethnicity | | | | | | <0.001 |
| Mexican American | 4,146 | 80.2 | 5.2 | 9.4 | 5.2 | |
| Non-Hispanic White | 3,354 | 86.1 | 5.0 | 5.9 | 3.1 | |
| Non-Hispanic Black | 4,000 | 81.1 | 4.9 | 8.2 | 5.8 | |
| Other | 884 | 83.8 | 3.8 | 8.7 | 3.7 | |
| Poverty income ratio (n=11,175) | | | | | | <0.001 |
| <1 | 3,735 | 82.5 | 4.7 | 8.4 | 4.3 | |
| 1–3 | 4,737 | 83.7 | 5.0 | 7.0 | 4.3 | |
| >3 | 2,703 | 86.8 | 4.8 | 5.9 | 2.5 | |

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**Table 2**

Prevalence of Morbid Obesity (BMI ≥ 40 kg/m$^2$) Among 6,849 U.S. Adolescents Ages 12–19 Years, NHANES 1999–2004 (no exclusion criteria)

| | n | % | 95% CI | p-value |
|---|---|---|---|---|
| **Total and Overall Percentage** | **6,849** | **1.3% (n=133) (418,000)** | **1.0–1.7** | |
| Sex | | | | 0.11 |
| Male | 3,456 | 1.0 | 0.7–1.4 | |
| Female | 3,393 | 1.6 | 1.1–2.5 | |
| Race/ethnicity | | | | <0.001 |
| Mexican American | 2,405 | 1.4 | 1.0–2.0 | |
| Non-Hispanic White | 1,766 | 0.9* | 0.5–1.7 | |
| Non-Hispanic Black | 2,129 | 3.4 | 2.8–4.2 | |
| Other | 549 | 0.6* | 0.2–1.6 | |
| Poverty income ratio (n=6,168) | | | | 0.02 |
| <1 | 1,959 | 2.0 | 1.4–2.9 | |
| 1–3 | 2,599 | 1.1 | 0.8–1.7 | |
| >3 | 1,610 | 0.8* | 0.4–1.6 | |

*Estimates based on sample size<30 or relative standard error>30% and may be unreliable

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### Table 3

Metabolic Factors by Weight Status Among U.S. Children Ages 2–19 years, NHANES 1999–2004 (excludes currently pregnant) fasting for 8 hours before testing

| | BMI 95–97th Percentile | BMI ≥99th Percentile | |
|---|---|---|---|
| | Mean (S.E.)<br>Median | Mean (S.E.)<br>Median | p-value |
| Waist circumference (cm) (n=2,148) | 87.17 (0.53)<br>90.0 | 97.39 (1.05)<br>98.7 | <0.001 |
| Systolic blood pressure (8–19 yrs) (n=1,675) | 111.32 (0.6)<br>111 | 114.9 (1.0)<br>115 | 0.001 |
| Diastolic blood pressure (8–19 yrs) (n=1,675) | 59.7 (0.6)<br>60 | 62.6 (0.9)<br>63 | 0.01 |
| Triglycerides (mg/dL) (3–19 yrs morning & fasting subsample) (n=800) | *99.3 (3.1)<br>97 | *111.4 (6.1)<br>112 | 0.10 |
| LDL (mg/dL) (3–19 yrs morning & fasting subsample) (n=789) | 101.1 (1.3)<br>97 | 99.7 (2.3)<br>100 | 0.62 |
| HDL (mg/dL) (3–19 yrs) (n=1,853) | 45.9 (0.4)<br>45 | 43.4 (0.7)<br>41 | <0.001 |
| Total cholesterol (mg/dL) (3–19 yrs) (n=1,855) | 170.5 (1.4)<br>168 | 167.8 (1.7)<br>166 | 0.18 |
| Insulin (μU/mL) (12–19 yrs fasting subsample) (n=518) | *16.04 (0.51)<br>15.91 | *27.47 (2.19)<br>24.47 | <0.001 |
| Plasma glucose (mg/dL) (12–19 yrs fasting subsample) (n=523) | 93.69 (0.75)<br>93.0 | 98.33 (2.67)<br>94.6 | 0.12 |
| ALT (U/L) (12–19 yrs) (n=1,172) | *21.73 (0.47)<br>20 | *28.72 (1.47)<br>28.72 | <0.001 |
| AST (U/L) (12–19 yrs) (n=1,172) | *22.74 (0.38)<br>22 | *25.20 (0.79)<br>24 | 0.01 |
| GGT (U/L) (12–19 yrs) (n=1,172) | *17.33 (0.39)<br>16 | *23.05 (1.03)<br>22 | <0.001 |
| Prevalence adult definition metabolic syndrome with glucose ≥ 100 (12–19 yrs fasting subsample) (n=523) | 16.9% (2.6) | 33.3% (7.1) | 0.04 |
| Prevalence adult definition metabolic syndrome with glucose ≥110 (12–19 yrs fasting subsample) (n=523) | 12.6% (2.2) | 31.5% (7.1) | 0.02 |

*Variables that were not normally distributed were log transformed for normality and then compared with the geometric mean (S.E.)