Associations Between Obesity and Comorbid Mental Health, Developmental, and Physical Health Conditions in a Nationally Representative Sample of US Children Aged 10 to 17

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ABSTRACT

OBJECTIVE: This large population-based study of US children considered the association of obesity with a broad range of comorbidities. This study examined relationships between weight status and health for US children.

METHODS: We performed cross-sectional analysis of data on 43,297 children aged 10 to 17 from the 2007 National Survey of Children's Health. Weight status was calculated from parent report of child height and weight. Logistic regression models assessed associations between weight status and 21 indicators of general health, psychosocial functioning, and specific health disorders, adjusting for sociodemographic factors.

RESULTS: Using body mass index (BMI) percentiles for age and sex, 15% of US children were considered overweight (BMI 85th to <95th percentile), and 16% were obese (BMI ≥95th percentile). Compared with children classified as not overweight, obese children were more likely to have reported good/fair/poor health (adjusted odds ratio [AOR] 2.18, 95% confidence interval [CI] 1.76–2.69), activity restrictions (AOR 1.39, 95% CI 1.10–1.75), internalizing problems (AOR 1.59, 95% CI 1.04–2.45), externalizing problems (AOR 1.33, 95% CI 1.07–1.65), grade repetition (AOR 1.57, 95% CI 1.24–1.99), school problems, and missed school days. Attention deficit/hyperactivity disorder, conduct disorder, depression, learning disability, developmental delay, bone/joint/muscle problems, asthma, allergies, headaches, and ear infections were all more common in obese children.

CONCLUSIONS: Obese children have increased odds of worse reported general health, psychosocial functioning, and specific health disorders. Physicians, parents, and teachers should be informed of the specific comorbidities associated with childhood obesity to target interventions that could enhance well-being. Future research should examine additional comorbidities and seek to confirm associations using longitudinal data and clinical measures of height and weight.

KEYWORDS: behavior problems; children; chronic health conditions; comorbidity; obesity

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WHAT'S NEW

This large population-based study of US children examined the association of obesity with a broad range of potential comorbidities. Associations were found between obesity and 19 indicators of general health, psychosocial functioning, and chronic health conditions.

CHILDHOOD OBESITY HAS dramatically increased over the last 2 decades.[1–3] Studies measuring the impact of the epidemic also warn of powerful long-term effects on adult morbidity and mortality, as well as health care costs.[4–6] The enduring consequences of childhood obesity not only include a growing number of obese adults, but also remarkable increases in comorbid conditions, including type 2 diabetes, heart disease, hypertension, and various mental health problems.[7] With a focus on childhood obesity's future consequences, there has been less attention paid to the nature, prevalence, and distribution of obesity-related comorbidities during childhood.

Unraveling the relationship of childhood obesity to other comorbid conditions is important for understanding the full impact of obesity in childhood. Although there is evidence that growing rates of childhood obesity relate to changes in caloric intake and caloric expenditure, as a result of a host of social trends and environmental changes, there are many other factors that may be contributing to increasing rates of obesity. Changes in exposures to chemical obesogens, higher levels of toxic stress, and obesity's relationship to the development of neuroregulatory processes associated with appetite, self-regulation, and impulse control are just some of the other causal pathways that have been considered.[8–10] A better understanding of the association of obesity with other health and psychosocial conditions in childhood may provide important information about

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developmental influences and causal pathways of obesity, as well as provide avenues for more effective primary, secondary, and tertiary prevention strategies.[11,12]

Prior studies have identified associations between obesity in childhood and adolescence and a broad range of health indicators and comorbidities, including general health status, health-related quality of life,[13–16] specific health conditions such as attention deficit/hyperactivity disorder (ADHD) and behavior problems,[17–21] asthma and respiratory infection,[22–24] orthopedic problems,[25] headaches,[26,27] and ear infections.[28] However, the vast majority of these studies have been based on small clinical or regional samples, which may not be representative of the general population of children. They also suffer from small sample sizes, which limit considerations of other sociodemographic confounders. Furthermore, most studies have examined associations one condition at a time instead of presenting a comprehensive profile of a broad range of health indicators that might be associated with childhood obesity.

The 2007 National Survey of Children's Health (NSCH) provides a unique opportunity to examine a comprehensive set of comorbidities of obesity with new data from a telephone survey of parents that is representative of the US population of children. We chose comorbid conditions on the basis of prior studies that suggested possible associations with obesity.[13–29] We examined the relationships between weight status and a broad set of mental health, developmental, and physical health comorbidities while controlling for other measures of social and economic status. We also examined whether the relationship between weight status and comorbid conditions vary for children from different socioeconomic and racial/ethnic groups.

METHODS

SAMPLE

The 2007 NSCH was conducted by the National Center for Health Statistics as a module of the State and Local Area Integrated Telephone Survey. The NSCH used a stratified random-digit-dial sampling design to achieve a nationally representative sample of 91,642 parents of children 0 to 17 years of age. One child was randomly selected from each household, and a detailed telephone interview was conducted with the parent or guardian who knew the most about the child's health and health care. Interviews of approximately 30 minutes were conducted in English and Spanish. The interview completion rate, measuring the proportion of age-eligible households that at least partially completed interviews among known households with children under 18 years of age, was 66.0%.

Because parent report of height and weight has been shown to overestimate overweight among young children, a finding based on population studies comparing obesity rates in different national data sets, NSCH only reports body mass index (BMI) for children in the age range of 10 to 17 years.[30] There were a total of 45,897 children in this age range, and 44,101 had valid data on reported height and weight. The final study sample was further restricted to exclude 804 individuals with missing data on any of the study covariates (N = 43,297) except household income, which was multiply imputed by NSCH statisticians.[31] A comparison of complete cases versus those with missing data revealed a higher tendency of nonresponse among black and Hispanic individuals and those with lower household income and education. There is a small amount of variability in sample size for each different comorbid health condition as a result of missing data on the condition (ranging from n = 43,297 to n = 41,976).

To produce population-based estimates, data records for each interview were assigned a sampling weight. NSCH weights were designed to minimize bias by incorporating adjustments for various forms of survey nonresponse including poststratification so the sample matches population control totals on key demographic variables obtained from the American Community Survey. Further details on the design and operation of NSCH are reported elsewhere.[31] This study was exempt from the UCLA institutional review board.

MEASURES

WEIGHT STATUS

Weight status of children was determined from calculations of BMI derived from parent-reported child height and weight. National Center for Health Statistics researchers categorized children as overweight if their BMI was in the 85th to <95th percentile compared with children of the same age and sex, and obese if their BMI was in the 95th percentile and above (continuous height and weight data were not available for public use). Percentiles were determined by Centers for Disease Control and Prevention growth charts.[31]

COMORBID HEALTH CONDITIONS

General health status indicators include parent-reported global child health status (dichotomized as excellent/very good vs good/fair/poor, following previous research)[32–35] and presence of an activity limitation, indicated by parent report of whether the child was "limited or prevented in any way in his/her ability to do things most children of the same age can do." Internalizing and externalizing problems were measured with selected items from the Behavior Problems Index.[36] Parents report how often (0 = never, 1 = rarely, 2 = sometimes, 3 = usually, 4 = always) the child feels worthless/inferior, is sad/depressed, is withdrawn (internalizing), argues too much, bullies or is cruel, is disobedient, and is stubborn/irritable (externalizing). Items were summed to create internalizing (range 0–12) and externalizing (0–16) scales. Scores above 6 on the internalizing scale and above 8 on the externalizing scale (corresponding with an answer of "sometimes" on each item) were used to classify problematic behavior. School functioning was assessed by parent report of a contact in the past year by the school about problems, if the child had ever repeated a grade, and number of school days missed as a result of illness (0–2, 3 or more).

A series of specific health conditions were assessed by parent report of whether a health care provider had ever

told them that the child had a "condition," and if so, if the child currently has the condition. An answer of yes to both questions identified children with the following mental health and developmental conditions: ADHD, conduct disorder, depression, anxiety, learning disability, and developmental delay. For physical health conditions, parents reported on children's dental health (excellent/very good vs good/fair/poor); whether the child currently had diabetes, bone/joint/muscle problems, and asthma; and whether a health care provider told them in the past year that their child had allergies (hay fever/respiratory, food/digestive, or eczema/skin), severe headaches, and ear infections. Number of specific comorbid health conditions was dichotomized as 0–2 and 3 or more.

Analysis

All statistical analyses were performed by STATA software, version 11.0 (StataCorp, College Station, Tex). Survey estimation procedures were applied, and the Taylor-series linearization method adjusted the standard errors for the complex survey design. Chi-square tests assessed differences in comorbidity prevalence by weight status. Logistic regression models added controls for household income (below 100% federal poverty level [FPL], 100%–199% FPL, 200%–299% FPL, 300%–399% FPL, 400% FPL or greater), family structure (2 parents, single mother, other caretakers/single fathers), race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, multiracial/other), highest parent education, child age in years, and child gender. These covariates were selected to determine possible confounding by major social and economic characteristics and match those used in the previous studies of obesity comorbidity.[13,14,16,20] Results are reported as odds ratios, which may overestimate relative risk, given the high prevalence (>10%) of many conditions. For school functioning outcomes (grade repetition and school problems), separate analyses also added controls for number of specific comorbid health conditions, which includes all mental health, developmental, and physical health conditions. For ADHD, separate regression models were run to exclude those taking stimulant medication, which might be expected to affect associations between weight status and ADHD. To determine whether associations between weight status and comorbid health conditions varied by sociodemographic factors, we tested statistical interactions between weight and household income, education, race/ethnicity, age in years, and gender in separate regression models including controls for confounders. Adjusted Wald tests assessed the statistical significance of interactions.

Results

Prevalence of Overweight and Obesity

The estimated prevalence of overweight based on parent-reported height and weight for all children aged 10 to 17 was 15% (95% confidence interval [CI] 14–16), and prevalence of obesity was 16% (95% CI 15–17). Wide social differentials in rates of overweight and obesity are apparent (Table 1). Obesity rates were nearly 3 times higher for children in poor families versus those at 400% FPL or greater (27% vs 10%), and nearly 2 times higher for black and Hispanic children versus white non-Hispanic children. Single-mother families, households with lower education, younger children, and boys also had elevated childhood obesity rates.

Comorbid Health Conditions by Weight Status

The prevalence of other health problems varied by weight status for 19 indicators (Table 2). Obese children had particularly high rates of other health problems. For example, 11% of obese children had an activity restriction compared with 7% classified as not overweight, 20% versus 10% repeated a grade, and 15% versus 9% had externalizing problems. Common health conditions associated with obesity include ADHD (12% of obese children vs 8% of those classified as not overweight), learning disability (15% vs 8%), good/fair/poor teeth (39% vs 27%), asthma (15% vs 9%), allergies (30% vs 26%), and headaches (9% vs 6%). Overall, obese children had nearly twice the risk of having 3 or more reported comorbid mental health, developmental, or physical health conditions (18% vs 10%), and overweight children had 1.3 times higher risk (13% vs 10%).

Adjusted and Unadjusted Odds of Health Problems by Weight Status

For 18 indicators, associations between weight status and health remained significant in logistic regression models with controls for sociodemographic factors (Table 3). Most significant differences occurred for children classified as obese versus not overweight, although overweight children had modestly elevated health complications across 5 indicators in adjusted models. Compared with children classified as not overweight, obese children were more likely to have good/fair/poor health (adjusted odds ratio [AOR] 2.18, 95% CI 1.76–2.69), activity restrictions (AOR 1.39, 95% CI 1.10–1.75), internalizing problems (AOR 1.59, 95% CI 1.04–2.45), externalizing problems (AOR 1.33, 95% CI 1.07–1.65), grade repetition (AOR 1.57, 95% CI 1.24–1.99), school problems, and more missed school days. Specific health conditions reported as more common for obese children included the following: ADHD, conduct disorder, depression, learning disability, developmental delay, asthma, bone/joint muscle problems, allergies, headaches, and ear infections. To determine whether associations between obesity and school functioning were explained by comorbid conditions, separate analyses included controls for the number of specific health conditions. Obesity was still associated with grade repetition (AOR 1.39, 95% CI 1.09–1.78) but not school problems (AOR 1.15, 95% CI 0.97–1.37).

A comparison of the adjusted and unadjusted odds ratios in Table 3 shows considerable attenuation in the magnitude of the associations between weight status and health after adjustment for sociosociodemographic factors. For example, there was a 57% reduction in the odds of conduct disorder for obese versus not overweight children. Despite

Table 1. Childhood Weight Status by Sociodemographic Factors for US Children Aged 10 to 17 From the 2007 National Survey of Children's Health*

Characteristic	Unweighted Sample Size (N)	Not Overweight % (95% CI)	Overweight % (95% CI)	Obese % (95% CI)	χ^2 *P*
Total	43,297	68 (67–70)	15 (14–16)	16 (15–17)	
Household income					<.001
<100% FPL	4,229	55 (51–58)	18 (15–21)	27 (25–30)	
100%–199% FPL	6,831	62 (59–65)	17 (15–19)	22 (19–24)	
200%–299% FPL	7,909	69 (66–71)	15 (13–17)	16 (14–18)	
300%–399% FPL	6,965	71 (68–74)	17 (14–20)	12 (10–14)	
400% FPL or greater	17,363	78 (76–79)	12 (11–14)	10 (9–12)	
Family structure					<.001
Two biological/adoptive parents	32,492	71 (69–72)	15 (14–16)	14 (13–16)	
Single mother	7,564	61 (58–64)	17 (15–19)	22 (20–24)	
Other	3,241	65 (62–69)	15 (13–18)	19 (17–22)	
Race/ethnicity					<.001
White, non-Hispanic	31,000	73 (72–74)	14 (13–15)	13 (12–14)	
Black, non-Hispanic	4,448	59 (56–62)	17 (15–20)	24 (22–26)	
Hispanic	4,312	59 (55–63)	18 (14–21)	23 (20–27)	
Multiracial/other	3,537	71 (67–75)	15 (13–19)	13 (10–16)	
Highest parent education					<.001
HS or less	10,071	60 (57–62)	17 (15–19)	23 (21–25)	
More than HS	33,226	73 (71–74)	14 (13–15)	13 (12–14)	
Child age					<.001
10–11 y	8,813	60 (58–63)	17 (15–19)	23 (21–25)	
12–13 y	10,046	66 (63–68)	17 (15–19)	17 (15–19)	
14–15 y	11,391	73 (71–75)	14 (12–15)	14 (12–15)	
16–17 y	13,047	74 (71–76)	13 (11–15)	13 (11–15)	
Child gender					<.001
Male	22,596	66 (64–67)	15 (14–16)	19 (18–21)	
Female	20,701	71 (70–73)	15 (14–17)	14 (12–15)	

CI = confidence interval; FPL = federal poverty level; HS = high school.
*Percentages are weighted to be nationally representative.

attenuation, AORs greater than 1.5 (obese vs not overweight) were noted for learning disability, developmental delay, asthma, bone/joint/muscle problems, headaches, and ear infections.

To determine whether associations between weight status and ADHD varied by use of stimulant medication, we estimated separate regression models. Obesity showed strong associations with ADHD for children not taking stimulant medication (vs not overweight: odds ratio 1.93, 95% CI 1.26–2.94; AOR 1.85, 95% CI 1.18–2.92), but there were no associations for children taking stimulant medication.

Because of concerns that associations between obesity and comorbid conditions could result from uncontrolled confounding, we chose 2 conditions with no prior evidence or existing rationale indicating an association with obesity. This analysis showed no association between obesity and minor vision problems and brain injury.

Statistical Interactions Between Weight Status and Sociodemographic Factors

There were few significant statistical interactions between childhood weight status and sociodemographic factors. For diabetes, there was a strong age-associated interaction. Coefficients from the interaction model showed that obesity predicted diabetes only for children beginning at age 15 (AOR 2.23, 95% CI 1.15–4.30), with odds increasing through age 17. Interactions between weight status and ethnicity were significant for global child health status and activity restriction (adjusted Wald $P < .05$). Tests of specific interaction coefficients revealed stronger obesity–health associations for white than for Hispanic children ($P < .05$). The magnitude of the obesity coefficient was smaller for Hispanic children (global child health AOR 1.62, 95% CI 1.02–2.58; activity restriction AOR 0.78, 95% CI 0.41–1.48) than white children (global child health AOR 3.00, 95% CI 2.23–4.06; activity restriction AOR 1.78, 95% CI 1.33–2.37). Similar trends were found for global health status and school illness days by family income: obesity showed stronger associations with health for higher-income children. There were no significant interactions between weight status and gender.

Discussion

Overweight and obesity were associated with poorer health status, lower emotional functioning, and school-related problems. Greater weight was also associated with higher rates of specific comorbid conditions, including ADHD, conduct disorders, depression, learning disabilities, developmental delay, good/fair/poor teeth, bone/joint/muscle problems, asthma, allergies, headaches, and ear infections. Although controlling for social status dampened the magnitude of these associations, most persisted. There was also a strong dose–response effect, with higher weight being associated with a higher prevalence of comorbid conditions and with greater numbers of comorbidities. Overweight children had somewhat elevated

Table 2. Prevalence of Health Problems by Childhood Weight Status for US Children Aged 10 to 17 From the 2007 National Survey of Children's Health*

Characteristic	Unweighted Sample Size (N)†	Overall Prevalence, % (95% CI)	Not Overweight, % (95% CI)	Overweight, % (95% CI)	Obese, % (95% CI)	χ^2 *P*
General health						
Good/fair/poor health	43,287	16 (15–17)	13 (12–14)	16 (14–18)	30 (27–34)	<.001
Activity restriction	43,240	7 (7–8)	7 (6–7)	7 (6–9)	11 (9–13)	<.001
Psychosocial functioning						
Internalizing problem	42,928	3 (2–3)	2 (2–3)	3 (2–5)	4 (3–6)	<.001
Externalizing problem	43,160	11 (10–12)	9 (9–10)	13 (11–16)	15 (13–17)	<.001
Repeat grade	43,219	12 (11–13)	10 (9–11)	12 (10–13)	20 (17–23)	<.001
School problems	41,976	31 (30–32)	29 (27–30)	31 (29–34)	40 (37–43)	<.001
≥3 missed school days	42,832	48 (46–49)	46 (45–48)	49 (45–52)	53 (50–56)	<.001
Mental health and developmental conditions						
ADHD	43,106	9 (8–10)	8 (8–9)	9 (8–11)	12 (10–14)	.003
Conduct disorder	43,248	4 (4–5)	3 (3–4)	5 (4–7)	7 (6–8)	<.001
Depression	43,211	3 (3–4)	3 (2–3)	4 (3–5)	4 (3–5)	.006
Anxiety	43,218	4 (3–4)	4 (3–4)	4 (3–6)	5 (4–6)	NS
Learning disability	43,137	10 (9–11)	8 (8–9)	10 (8–12)	15 (13–17)	<.001
Developmental delay	43,208	3 (3–4)	3 (2–3)	3 (2–5)	6 (5–8)	<.001
Physical health condition						
Good/fair/poor teeth	43,279	29 (28–30)	27 (25–28)	30 (27–33)	39 (36–42)	<.001
Diabetes	43,271	0.7 (0.5–0.9)	0.7 (0.4–1.0)	0.5 (0.3–0.8)	0.9 (0.5–1.5)	NS
Bone/joint/muscle problem	43,237	3 (3–4)	3 (2–3)	3 (2–4)	5 (3–7)	.026
Asthma	43,202	11 (10–11)	9 (8–10)	12 (10–14)	15 (13–18)	<.001
Allergies	43,192	27 (26–28)	26 (25–28)	29 (27–32)	30 (27–33)	.025
Headaches	43,259	7 (6–7)	6 (5–7)	8 (6–10)	9 (7–11)	.001
Ear infections	43,276	3 (2–3)	2 (2–2)	2 (2–3)	5 (4–7)	<.001
≥3 comorbid conditions	42,484	12 (11–13)	10 (9–11)	13 (11–15)	18 (15–21)	<.001

CI = confidence interval; ADHD = attention deficit/hyperactivity disorder; NS = not statistically significant.

*Percentages are weighted to be nationally representative.

†There is some variability in sample size as a result of missing data on comorbid health conditions.

prevalence of having 3 or more reported comorbid conditions compared with those not overweight (13% vs 10%), and obese children were nearly 2 times more likely to have multiple reported comorbidities (18% vs 10%).

The cross-sectional nature of the data limits our ability to determine whether obesity is causing the comorbid condition (ie, a complication), whether the comorbid condition is responsible for obesity, or if both are related to some unmeasured third factor. One possibility is obesity could directly contribute to the development of other health problems. Diabetes is a good example of a direct complication of obesity. A less obvious example is headache frequency and severity, which have been shown to improve if a patient loses weight.[37] Furthermore, obesity has been linked with increased prevalence of otitis media with effusion. The proposed mechanisms for this include altered cytokine expression, gastroesophageal reflux disease, or fat accumulation.[38] In some instances, causal relations could run in both directions. For example, depression could alter healthy eating and exercise patterns, whereas greater weight gain could lead to more depression.[39] A third possibility is that obesity and comorbid conditions could share common antecedent risk factors. For example, some evidence suggests the relationship between obesity and ADHD may be due to the experience of toxic stress in the early years, resulting in alterations in executive function that result in poor impulse control as well as leptin insensitivity, which can contribute to weight gain.[9,10] The relationship between obesity and the development of asthma is similarly complex, with causal arrows pointing in both directions.[40,41]

It is noteworthy that the association of obesity with ADHD was strong for those not taking stimulant medications, but there were no associations for children taking stimulants. This might suggest that children who are untreated for their ADHD might have other risk factors for obesity, or that stimulant medication reduces the risk of obesity by decreasing appetite and improving impulse control. Future longitudinal research is needed to tease out the causal relationships embedded in these associations and to explore whether associations remain with control subjects for additional explanatory or confounding factors.

Higher-weight-status categories were consistently associated with more health problems. This has been found in other studies.[10,19] Obesity showed stronger and more consistent relationships with other health problems than overweight, which might be expected because overweight is defined by individuals within a narrow weight band (85th to <95th percentile of BMI), while obesity is an unbounded category including the severely obese. The relatively modest and less consistent associations between overweight status and poorer health could also arise because the overweight category is likely to include individuals with high lean body mass (eg, wrestlers, soccer players, football players) because BMI does not specifically measure body fat contribution to body weight.

Table 3. Unadjusted and Adjusted Odds of Health Problems by Childhood Weight Status for US Children Aged 10 to 17 From the 2007 National Survey of Children's Health

Characteristic	Unweighted Sample Size (N)†	Unadjusted Odds (Reference = Not Overweight) (95% CI)		Adjusted Odds (95% CI)‡	
		Overweight	Obese	Overweight	Obese
General health					
Good/fair/poor health	43,287	1.30 (1.07–1.57)*	2.94 (2.44–3.56)*	1.09 (0.89–1.35)	2.18 (1.76–2.69)*
Activity restriction	43,240	1.15 (0.91–1.47)	1.79 (1.43–2.24)*	1.04 (0.81–1.32)	1.39 (1.10–1.75)*
Psychosocial functioning					
Internalizing problem	42,928	1.67 (1.04–2.67)*	2.20 (1.44–3.35)*	1.43 (0.88–2.31)	1.59 (1.04–2.45)*
Externalizing problem	43,160	1.46 (1.14–1.87)*	1.65 (1.35–2.01)*	1.32 (1.02–1.71)*	1.33 (1.07–1.65)*
Repeat grade	43,219	1.15 (0.95–1.39)	2.14 (1.73–2.66)*	1.00 (0.82–1.23)	1.57 (1.24–1.99)*
School problems	41,976	1.12 (0.97–1.30)	1.65 (1.41–1.92)*	1.01 (0.87–1.17)	1.28 (1.08–1.50)*
≥3 missed school days	42,832	1.10 (0.96–1.26)	1.30 (1.13–1.50)*	1.13 (0.99–1.30)	1.39 (1.20–1.61)*
Mental health and developmental conditions					
ADHD	43,106	1.10 (0.89–1.37)	1.45 (1.15–1.83)*	1.07 (0.86–1.34)	1.29 (1.01–1.65)*
Conduct disorder	43,248	1.61 (1.15–2.26)*	2.15 (1.61–2.85)*	1.41 (1.00–2.00)*	1.50 (1.13–2.00)*
Depression	43,211	1.37 (1.01–1.87)*	1.51 (1.14–2.01)*	1.33 (0.98–1.82)	1.41 (1.04–1.93)*
Anxiety	43,218	1.21 (0.89–1.65)	1.33 (1.03–1.72)*	1.21 (0.88–1.65)	1.27 (0.95–1.70)
Learning disability	43,137	1.20 (0.93–1.55)	1.89 (1.52–2.35)*	1.12 (0.87–1.45)	1.57 (1.24–1.98)*
Developmental delay	43,208	1.25 (0.80–1.96)	2.37 (1.65–3.41)*	1.15 (0.74–1.79)	1.97 (1.38–2.81)*
Physical health conditions					
Good/fair/poor teeth	43,279	1.17 (1.01–1.36)*	1.75 (1.51–2.04)*	0.94 (0.80–1.11)	1.14 (0.97–1.33)
Diabetes	43,271	0.71 (0.37–1.34)	1.32 (0.68–2.59)	0.74 (0.38–1.43)	1.47 (0.72–3.03)
Bone/joint/muscle problem	43,237	1.12 (0.80–1.55)	1.69 (1.09–2.61)*	1.16 (0.82–1.63)	1.83 (1.14–2.93)*
Asthma	43,202	1.35 (1.08–1.68)*	1.76 (1.42–2.17)*	1.30 (1.05–1.62)*	1.61 (1.28–2.03)*
Allergies	43,192	1.16 (1.00–1.35)*	1.19 (1.02–1.39)*	1.20 (1.03–1.39)*	1.28 (1.09–1.50)*
Headaches	43,259	1.41 (1.07–1.84)*	1.51 (1.18–1.93)*	1.43 (1.10–1.87)*	1.56 (1.21–2.01)*
Ear infections	43,276	1.71 (0.88–1.57)	2.69 (1.85–3.92)*	1.04 (0.77–1.40)	2.22 (1.55–3.17)*
≥3 comorbid conditions	42,484	1.33 (1.07–1.63)*	1.86 (1.53–2.25)*	1.23 (0.99–1.52)	1.53 (1.24–1.89)*

CI = confidence interval; ADHD = attention deficit/hyperactivity disorder.

*Statistically signficant at $P < .05$.

†There is some variability in sample size as a result of missing data on comorbid health conditions.

‡Models include controls for child age, gender, race/ethnicity, parent education, household income, and family structure.

Steep social gradients in obesity prevalence and attenuation in coefficients when sociodemographic factors were included in regression models suggest that social risk factors contribute to some of the overlap between obesity and other health problems. A strong age interaction effect was found for diabetes, with associations becoming statistically significant at ages 15 to 17. Although the relationship between obesity and adult-onset diabetes is well established,[42–44] these data suggest the relationship between obesity and diabetes is well under way beginning in adolescence. There was also some evidence obesity might have greater influence on health for higher-income or white children. Other studies have noted similar findings,[13,45,46] although the reasons are not clear. It could be that more disadvantaged children face many other risk factors and exposures, in addition to obesity, that take an even greater toll on their overall health than their weight status.

Associations between weight status and repeating a grade were independently associated with obesity and were not explained by the presence of other measured comorbid conditions. These findings are consistent with an emerging literature demonstrating possible linkages between obesity and lowered academic achievement measured by grade point average, test scores, and performance motivation.[47–50] Higher rates of obesity-associated internalizing and externalizing behavior problems have also been noted in prior clinical studies.[51,52] Although we cannot address causal mechanisms, there is a large literature linking childhood overweight with risk factors for the development of psychosocial problems, including weight-based teasing, social stigmatization, and peer rejection.[53–56]

The strengths of this study lie in the large population-based nature of the NSCH, which allows us to present the first comprehensive national profile examining associations between weight status and a broad set of comorbid conditions for US children. The main limitations are the cross-sectional nature of the data and the reliance on parental report of child height, weight, and comorbid conditions. Previous research has shown a high correlation between parent or self-reported and measured height and weight for adolescents.[57,58] Evidence from population studies comparing prevalence estimates derived from direct measurement versus parent report suggest fairly good convergence for children aged 10 to 17.[59] However, analyses comparing prevalence rates by detailed age categories between NSCH and National Health and Nutrition Examination Survey (NHANES) suggest a possible overestimation of obesity rates for children aged 10 to 11 and underestimation of obesity rates for children aged 14 to 17, which may help explain the wider age differences in obesity observed in NSCH.[30] Because the obesity rates did appear a bit high for 10- to 11-year-olds in our sample compared to other studies, analyses were run excluding these children, and the results were the same. Furthermore, a comparison of the findings of our study with a wide range of smaller-scale regional and clinic-based studies using

other methods of case ascertainment, including clinical assessment of weight status and comorbidity, revealed a similar pattern and magnitude of associations between obesity and a broad range of comorbid conditions such as ADHD,[29] asthma,[22,23] orthopedic problems,[25] headaches,[27,60] and ear infections.[28] This gives us confidence that our estimates are valid reflections of comorbidity patterns for US children.

CONCLUSIONS

The past 20 years have shown dramatic increases in the prevalence of childhood obesity, with recent studies showing that obesity has almost doubled between 1988 and 2006.[3,61] This same time period has also shown large increases in the prevalence of other childhood-onset health conditions such as ADHD, conduct problems, learning difficulties, and asthma.[62,63] The finding that comorbid conditions tend to cluster within individuals and that there are common social risk factors that might contribute to the development of both overweight and comorbid conditions suggest the possibility of a common origin for this shifting pattern of morbidity. We can speculate that this major ongoing shift in the epidemiology of chronic childhood health conditions is likely to be related to recent shifts in the social and physical environment of childhood, which includes more social and lifestyle risk exposures.[64] It also suggests that effective approaches to preventing obesity are likely to have beneficial effects in preventing related comorbid conditions.

Our findings suggest that obesity prevention efforts should target the social determinants of obesity and related comorbid health conditions. Our findings also suggest that treatment of childhood obesity should include screening for comorbid conditions that may require simultaneous management. Our results indicate obese children are at heightened risk of many different forms of suboptimal health outcomes, and that early prevention and intervention efforts are warranted to address concurrent health problems as well as possible future health risks associated with childhood obesity. Future research should seek to confirm the associations reported in this study using clinical measures of height and weight and longitudinal designs that allow for the investigation of which conditions came first.

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REFERENCES

1. Ogden CL, Flegal KM, Carroll MD, et al. Prevalence and trends in overweight among US children and adolescents, 1999–2000. *JAMA*. 2002;288:1728–1732.
2. Ogden CL, Carroll MD, Curtin LR, et al. Prevalence of overweight and obesity in the United States, 1999–2004. *JAMA*. 2006;295:1549–1555.
3. Perrin JM, Bloom SR, Gortmaker SL. The increase of childhood chronic conditions in the United States. *JAMA*. 2007;297:2755–2759.
4. Dietz WH. Childhood weight affects adult morbidity and mortality. *J Nutr*. 1998;128(2 suppl):411S–414S.
5. Olshansky SJ, Passaro DJ, Hershow RC, et al. A potential decline in life expectancy in the United States in the 21st century. *N Engl J Med*. 2005;352:1138–1145.
6. Trasande L. How much should we invest in preventing childhood obesity? *Health Aff (Millwood)*. 2010;29:372–378.
7. Reilly J, Methven E, McDowell Z, et al. Health consequences of obesity. *Arch Dis Child*. 2003;88:748–752.
8. Baillie-Hamilton PF. Chemical toxins: a hypothesis to explain the global obesity epidemic. *J Altern Complement Med*. 2002;8:185–192.
9. Garasky S, Stewart SD, Gundersen C, et al. Family stressors and child obesity. *Soc Sci Res*. 2009;38:755–766.
10. Teicher MH, Andersen SL, Polcari AP, et al. Developmental neurobiology of childhood stress and trauma. *Psychiatr Clin N Am*. 2002;25:397–426.
11. Tanda R, Salsberry PJ. Integrating risks for type 2 diabetes across childhood: a life course perspective. *J Pediatr Nurs*. 2012;27:310–318.
12. Symonds ME, Sebert S, Budge H. The obesity epidemic: from the environment to epigenetics—not simply a response to dietary manipulation in a thermoneutral environment. *Front Genet*. 2011;2:24.
13. Swallen KC, Reither EN, Haas SA, et al. Overweight, obesity, and health-related quality of life among adolescents: the National Longitudinal Study of Adolescent Health. *Pediatrics*. 2005;115:340–347.
14. Skinner AC, Mayer ML, Flower K, et al. Health status and health care expenditures in a nationally representative sample: how do overweight and healthy-weight children compare? *Pediatrics*. 2008;121:e269–e277.
15. Wijga AH, Scholtens S, Bemelmans WJ, et al. Comorbidities of obesity in school children: a cross-sectional study in the PIAMA birth cohort. *BMC Public Health*. 2010;10:184.
16. Williams J, Wake M, Hesketh K, et al. Health-related quality of life of overweight and obese children. *JAMA*. 2005;293:70–76.
17. Hubel R, Jass J, Marcus A, et al. Overweight and basal metabolic rate in boys with attention-deficit/hyperactivity disorder. *Eat Weight Disord*. 2006;11:139–146.
18. Agranat-Meged AN, Deitcher C, Goldzweig G, et al. Childhood obesity and attention deficit/hyperactivity disorder: a newly described comorbidity in obese hospitalized children. *Int J Eat Disord*. 2005;37:357–359.
19. Waring ME, Lapane KL. Overweight in children and adolescents in relation to attention-deficit/hyperactivity disorder: results from a national sample. *Pediatrics*. 2008;122:e1–e6.
20. BeLue R, Francis LA, Colaco B. Mental health problems and overweight in a nationally representative sample of adolescents: effects of race and ethnicity. *Pediatrics*. 2009;123:697–702.
21. Eschenbeck H, Kohlmann CW, Dudey S, et al. Physician-diagnosed obesity in German 6- to 14-year-olds. Prevalence and comorbidity of internalising disorders, externalising disorders, and sleep disorders. *Obes Facts*. 2009;2:67–73.
22. Story RE. Asthma and obesity in children. *Curr Opin Pediatr*. 2007;19:680–684.
23. Tai A, Volkmer R, Burton A. Association between asthma symptoms and obesity in preschool (4–5 year old) children. *J Asthma*. 2009;46:362–365.
24. Cockrell Skinner A, Perrin EM, Steiner MJ. Healthy for now? A cross-sectional study of the comorbidities in obese preschool children in the United States. *Clin Pediatr (Phila)*. 2010;49:648–655.
25. Taylor ED, Theim KR, Mirch MC, et al. Orthopedic complications of overweight in children and adolescents. *Pediatrics*. 2006;117:2167–2174.
26. Kinik ST, Alehan F, Erol I, et al. Obesity and paediatric migraine. *Cephalalgia*. 2010;30:105–109.
27. Pinhas-Hamiel O, Frumin K, Gabis L, et al. Headaches in overweight children and adolescents referred to a tertiary-care center in Israel. *Obesity (Silver Spring)*. 2008;16:659–663.

28. Kim JB, Park DC, Cha CI, et al. Relationship between pediatric obesity and otitis media with effusion. *Arch Otolaryngol Head Neck Surg*. 2007;133:379–382.
29. Cortese S, Angriman M, Maffeis C, et al. Attention-deficit/hyperactivity disorder (ADHD) and obesity: a systematic review of the literature. *Crit Rev Food Sci Nutr.* 2008;48:524–537.
30. Akinbami LJ, Ogden CL. Childhood overweight prevalence in the United States: the impact of parent-reported height and weight. *Obesity (Silver Spring)*. 2009;17:1574–1580.
31. Blumberg S, Foster E, Frasier A, et al. Design and operation of the National Survey of Children's Health, 2007. National Center for Health Statistics. *Vital Health Stat 1*. 2012;55:1–149.
32. Flores G, Tomany-Korman SC. Racial and ethnic disparities in medical and dental health, access to care, and use of services in US children. *Pediatrics*. 2008;121:e286–e298.
33. Teranishi K, Hayes DK, Iwaishi LK, et al. Poorer general health status in children is associated with being overweight or obese in Hawai'i: findings from the 2007 National Survey of Children's Health. *Hawaii Med J*. 2011;70(7 suppl 1):16–20.
34. Larson K, Russ SA, Crall JJ, et al. Influence of multiple social risks on children's health. *Pediatrics*. 2008;121:337–344.
35. Larson K, Halfon N. Family income gradients in the health and health care access of US children. *Matern Child Health J*. 2010;14:332–342.
36. Peterson JL, Zill N. Marital disruption, parent–child relationships, and behavioral problems in children. *J Marriage Fam.* 1986;48: 295–307.
37. Hershey AD, Powers SW, Nelson TD, et al. Obesity in the pediatric headache population: a multicenter study. *Headache*. 2009;49: 170–177.
38. Lee SK, Yeo SG. Relationship between pediatric obesity and otitis media with effusion. *Curr Allergy Asthma Rep*. 2009;9:465–472.
39. Luppino FS, de Wit LM, Bouvy PF, et al. Overweight, obesity, and depression: a systematic review and meta-analysis of longitudinal studies. *Arch Gen Psychiatry.* 2010;67:220–229.
40. Beuther DA. Recent insight into obesity and asthma. *Curr Opin Public Med.* 2010;16:64–70.
41. Beuther DA, Sutherland ER. Overweight, obesity, and incident asthma: a meta-analysis of prospective epidemiologic studies. *Am J Respir Crit Care Med*. 2007;175:661–666.
42. Brancati FL, Wang NY, Mead LA, et al. Body weight patterns from 20 to 49 years of age and subsequent risk for diabetes mellitus: the Johns Hopkins Precursors Study. *Arch Intern Med.* 1999;159:957–963.
43. Morrison JA, Glueck CJ, Horn PS, et al. Childhood predictors of adult type 2 diabetes at 9- and 26-year follow-ups. *Arch Pediatr Adolesc Med*. 2010;164:53–60.
44. Yeung EH, Zhang C, Buck Louis GM, et al. Childhood size and life course weight characteristics in association with the risk of incident type 2 diabetes. *Diabetes Care*. 2010;33:1364–1369.
45. Cossrow N, Falkner B. Race/ethnic issues in obesity and obesity-related comorbidities. *J Clin Endocrinol Metab.* 2004;89:2590–2594.
46. Fallon EM, Tanofsky-Kraff M, Norman AC, et al. Health-related quality of life in overweight and nonoverweight black and white adolescents. *J Pediatr.* 2005;147:443–450.
47. Datar A, Sturm R. Childhood overweight and elementary school outcomes. *Int J Obes (Lond)*. 2006;30:1449–1460.
48. Krukowski RA, West DS, Perez AP, et al. Overweight children, weight-based teasing and academic performance. *Int J Pediatr Obes*. 2009;4:274–280.
49. Mo-suwan L, Lebel L, Puetpaiboon A, et al. School performance and weight status of children and young adolescents in a transitional society in Thailand. *Int J Obes Relat Metab Disord*. 1999;23: 272–277.
50. Taras H, Potts-Datema W. Obesity and student performance at school. *J Sch Health*. 2005;75:291–295.
51. Vila G, Zipper E, Dabbas M, et al. Mental disorders in obese children and adolescents. *Psychosom Med.* 2004;66:387–394.
52. Lumeng JC, Gannon K, Cabral HJ, et al. Association between clinically meaningful behavior problems and overweight in children. *Pediatrics*. 2003;112:1138–1145.
53. Goldfield A, Chrisler JC. Body stereotyping and stigmatization of obese persons by first graders. *Percept Mot Skills*. 1995;81(3 pt 1): 909–910.
54. Haines J, Neumark-Sztainer D, Hannan PJ, et al. Longitudinal and secular trends in weight-related teasing during adolescence. *Obesity (Silver Spring)*. 2008;16(suppl 2):S18–S23.
55. Hayden-Wade HA, Stein RI, Ghaderi A, et al. Prevalence, characteristics, and correlates of teasing experiences among overweight children vs non-overweight peers. *Obes Res*. 2005;13:1381–1392.
56. Latner JD, Stunkard AJ. Getting worse: the stigmatization of obese children. *Obes Res*. 2003;11:452–456.
57. Goodman E, Hinden BR, Khandelwal S. Accuracy of teen and parental reports of obesity and body mass index. *Pediatrics*. 2000; 106:52–58.
58. Brener ND, McManus T, Galuska DA, et al. Reliability and validity of self-reported height and weight among high school students. *J Adolesc Health*. 2003;32:281–287.
59. Singh GK, Kogan MD, Van Dyck PC, Siahpush M. Racial/ethnic, socioeconomic, and behavioral determinants of childhood and adolescent obesity in the United States: analyzing independent and joint associations. *Ann Epidemiol*. 2008;18:682–695.
60. Kinik S, Alehan F, Erol I, et al. Obesity and paediatric migraine. *Cephalalgia*. 2010;30:105–109.
61. Van Cleave J, Gortmaker SL, Perrin JM. Dynamics of obesity and chronic health conditions among children and youth. *JAMA*. 2010; 303:623–630.
62. Newacheck PW, Halfon N. Prevalence, impact, and trends in childhood disability due to asthma. *Arch Pediatr Adolesc Med*. 2000; 154:287–293.
63. Pastor PN, Rueben CA. Diagnosed attention deficit hyperactivity disorder and learning disability. *Vital Health Stat 10*. 2008;237:1–14.
64. Halfon N, Newacheck PW. Evolving notions of childhood chronic illness. *JAMA*. 2010;303:665–666.