Bias in Estimates of Child Obesity from Panel Surveys

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ABSTRACT

Parental reporting of height and weight was evaluated for US children ages 2-13. Obesity prevalence (body-mass-index ≥95th percentile) and its height and weight components were compared in child supplements of two nationally-representative surveys (the National Longitudinal Survey of Youth, 1996-2008, and the Panel Study of Income Dynamics, 1997-2002). Standardization/decomposition methods were adapted to quantify overall bias in obesity prevalence relative to measured data from the National Health and Nutrition Examination Survey, and to examine the contributions to that bias arising from error in reporting extreme weight versus extreme height values. Parental under-reporting of both height and weight was found. Much greater bias in obesity prevalence estimates, however, arose from height under-reporting. Under-reporting of height decreased with age and under-reporting of weight increased with age. Based on our findings, we offer practical solutions for survey data collection and research on child obesity using parent-reported data.

The recommended method for surveillance and routine clinical assessments of child overweight and obesity is to calculate Body Mass Index (BMI) from height and weight measured by trained personnel(1-6). Due to cost and practicality, however, survey data with parent-reported or self-reported height and weight are often used(7-12). Considerable skepticism has been expressed by researchers and health professionals about the accuracy of parent-reported data and the validity of findings drawn from surveys in which children's height and weight are parent-reported(8,13-18).

Studies evaluating the quality of parent-reported data(7,8,13-23) have been inconsistent on the magnitude and direction of error in parent-reported weight, height, and calculated BMI(5). Most samples are from non-U.S. populations in which metric rather than imperial measurement systems are used(14-17,19,20), or are convenience samples of U.S. children(18,21-23). Because obesity is defined as BMI at or above a high threshold point, for example the U.S. Centers for Disease Control and Prevention's (CDC) 95th percentile(1-4), sensitivity of obesity prevalence to error in extreme values of height and weight, especially very high weight or very low height, is high. This possibility is recognized in the CDC and World Health Organization protocols to identify "biologically implausible" values of height or weight(24). Parental over-reporting of extreme values of height or weight has been attributed to digit preference, rounding, and failing to keep pace with children's rapid growth especially at the youngest ages(8). Parental under-reporting of extreme values has also been observed, with parents of heavy children under-reporting weight and parents of light children over-reporting weight(13-15,19,21,23). This latter type of reporting error can be interpreted either as simple regression to the mean(25) or as arising from social desirability bias(23,26-28).

Because increases in weight have driven the obesity epidemic, it is unsurprising that studies have tended to emphasize the measurement or reporting of weight rather than height(29,30). At least equal attention to height mis-measurement or mis-reporting, however, is merited since height errors are compounded by the squaring of height in the denominator of BMI(7,8). To our knowledge, no previous study has assessed quantitatively the contributions to bias in obesity prevalence estimation due to errors in reporting height versus reporting weight. We conduct such an assessment for children aged 2 through 13 in two nationally-representative U.S. surveys.

METHODS

Data

The Children of the National Longitudinal Survey of Youth 1979 (NLSY79-Child) is an ongoing survey of children of NLSY79 women with biennial assessments of height and weight. NLSY79 women are nationally-representative of women aged 14-21 in 1979, and include an oversample of non-Hispanic black and non-Hispanic white economically disadvantaged households. They have been surveyed annually through 1994 with retention rates above 90%, and biennially since 1994 with retention rates between 80% and 90%(31). Children are eligible for assessment in the NLSY79-Child if they are younger than age 15, their mother was assessed in the corresponding NLSY79 wave,

they resided at least part-time with their mother, and their mother provided informed consent. The proportion of eligible children who were either directly assessed or whose mothers' were interviewed ranged from a low of 77% in 2000 (a single-year when, for budgetary reasons, NLSY79 oversamples of blacks and Hispanics were not interviewed) to a high of 96% in 1996(32). Our sample comprises children from the 1996 through 2008 survey waves observed at age 2-13 (n=6,373 children over 20,196 person-years), from which we excluded observations where children reported their own height and/or weight (3%) or height and/or weight was not assessed (3%).

A second nationally-representative panel survey, the Panel Study of Income Dynamics (PSID), has conducted Child Development Supplements in 1997 (CDS-I), 2002/3 (CDS-II), and 2007/8 (CDS-III). The PSID has followed since 1968 a nationally-representative sample of U.S. households, including a low-income oversample. All new households formed by children and other family members descended from the original 1968 households are followed. An immigrant "refresher" subsample was added in 1997. Wave-to-wave retention rates have ranged from 92% to 98%, following the initial 1968 and 1969 response and retention rates of 76% and 81%, respectively(33). The CDS-I was administered in 1997 to primary caregivers (PCG) of up to two randomly selected children ages 0 to 12 in the PSID core and immigrant refresher samples. CDS-I children whose parents remained in the PSID panel and who provided informed consent were assessed again in the 2002/3 CDS-II. Response rates were 88% and 91% respectively for the CDS-I and CDS-II(34,35). Our sample comprises children aged 2-13 in CDS-I (n=3,113) and 6-13 in CDS-II (n=1,815), from which we exclude observations in the CDS-I (10%) and CDS-II (9%) for which height and/or weight was not assessed.

The National Health and Nutrition Examination Surveys (NHANES) are an ongoing series of annual cross-sectional surveys of the U.S. civilian non-institutionalized population(36). Children ages 2 to14 are sampled as part of a nationally-representative multistage probability sample that oversamples African Americans, Hispanics, and low income households. Response rates for the sample of children were between 81% and 88%(37). Our NHANES sample comprises children aged 2 to 13 surveyed in 1999-2008 (n= 12,726), from which we exclude observations in which height and/or weight was not assessed (3%).

Assessment of height and weight. In both the NLSY-Child and PSID-CDS, height was recorded in feet and inches, and weight in pounds and ounces. At each survey wave of the NLSY-Child (henceforth NLSY), a trained interviewer or the mother measured children's heights and weights unless the mother did not consent to either measurement or the interview was conducted by telephone, in which cases height and/or weight was mother-reported. Measurements were taken in the children's own clothes, with shoes and coats removed, using a portable scale and tape measure. Survey flags identify whether height and weight were reported or measured. Additionally, in the NLSY 2006 and 2008 waves only, a subset of children had both mother-reported and measured height and weight in a given survey wave.

In the PSID, height and weight protocols changed between CDS-I and CDS-II. In CDS-I, weight was reported by the Primary Caregiver (PCG). PCGs who did not know the child's weight were asked to provide an estimate and report when the child was last weighed. Child height was measured by a trained interviewer unless the interview was conducted by phone, the child was not present, or the PCG did not consent(38). Unfortunately, no flag is provided with the data to distinguish parent-reported from measured heights or to distinguish whether an interview was conducted in-person or by phone. However, we were able to develop a proxy-flag for whether or not the child was a 'non-respondent' on the in-person child assessment for children age 3-12, thereby identifying children whose PCG was interviewed by phone or who were otherwise not present for assessment and thus could not have had an interviewer-measured height(38). In the CDS-II, both height and weight were interviewer-measured, using a tape measure and portable scale, with shoes and heavy items removed. In this wave, survey flags identify children not measured due to lack of consent or other limitations, who we exclude (n=19).

Because children in the NLSY and PSID were not randomly selected into measured versus parent-reported height and weight assessments, we compared the social and demographic characteristics of the children in each survey by assessment protocol (see Appendix 1). In the NLSY, children in later survey years were more likely to have parent-reported than measured data. Children born to older mothers, non-Hispanic Black mothers, and mothers with higher family incomes were more heavily represented in these later survey years, and therefore also in the parent-reported subsamples. All of these characteristics are associated with lower rates of obesity(39-41). In the PSID CDS-I, there were no differences between the subsamples on gender, mother's age, or family income. The parent-reported subsample, however, was more likely to be Hispanic but less likely to be non-Hispanic black; both minority groups have higher rates of obesity(29,42).

In the NHANES, height and weight were measured by trained health technologists during a separate physical assessment at a Mobile Examination Center (MEC) and recorded in increments of 0.1 kilograms and 0.1 centimeters. Children were measured and weighed in their underwear with a paper gown and foam slippers. Supervisors monitored quality control and calibration of the equipment. Data collection software range-checked each measurement and required confirmation before accepting values below the 1st percentile or above the 99th percentile for age and sex based on the CDC references(43).

Analyses

Children were categorized into percentiles of height-for-age, weight-for-age, and BMI-for-age on the basis of gender and age in months using a SAS program from the CDC that employs the 2000 CDC growth charts(24,43). We excluded a small number of observations in the NLSY (n=20) and PSID (n=2) with BMI outside the range of this program. BMI-for-age at or above the 95th percentile was classified as 'obese'(2). The panel surveys were divided into 4 subsamples distinguishing measured from reported

height and weight, and into age groupings for which there was sufficient sample size within those subsamples: ages 2-5, 6-8, 9-11, and 12-13 in the NLSY; ages 2-5 and 6-13 in the PSID-CDS-I; and ages 6-13 in the PSID-CDS-II (see Table 1). Equivalent NHANES age groups were constructed, pooling the 1999-2008 surveys to obtain adequate sample sizes, since child obesity prevalence changed little over this period(44). Obesity prevalence was compared, and percentile-by-percentile comparisons of children above or below each of the top or bottom 20 percentiles of weight-for-age and height-for-age were conducted.

Estimated panel survey bias induced by mis-reporting or mis-measuring very high weight or very low height was calculated using the NHANES as an unbiased standard. Very high weight (w) was first defined as weight-for-age above the 99th percentile. Obesity prevalence, $P(obese)$, was expressed as a function of the percentage of children who did, $P(w>99)$, and did not, $P(w\leq 99)$, have very high weight, and the percent prevalence of obesity among those who did, $P(obese|w>99)$, and did not, $P(obese|w\leq 99)$, have very high weight:

$$P(obese) = P(obese \mid w > 99) * P(w > 99) + P(obese \mid w \leq 99) * P(w \leq 99)$$

Expected NLSY or PSID obesity prevalence after removing bias in $P(w>99)$ and $P(obese|w>99)$ was calculated by substituting the NHANES values of $P(w>99)$ and $P(obese|w>99)$ into the above equation while retaining the NLSY or PSID values of $P(w\leq 99)$ and $P(obese|w\leq 99)$. The bias induced by mis-reporting or mis-measuring very high weight was then calculated by subtracting the expected from observed panel survey prevalence. Bias induced by mis-reporting and mis-measuring weight above the 98th and 95th percentiles, and bias due to very low height (i.e., below the 1st, 2nd, and 5th percentiles) were calculated analogously. Because the NHANES had few cases with height below the 1st and 2nd percentiles, however, the NHANES percentage of children obese with height below the 5th percentile was substituted for the panel survey percentages of children obese with height below the 1st and 2nd percentiles.

Finally, for the subset of NLSY observations with both measured and parent-reported height and weight, mean differences between the measured and parent-reported data for a given assessment of BMI, height, and weight were calculated.

All analyses employed survey weights and adjusted for the stratified survey design of the NHANES and for clustering of children in families in the NLSY-Child and PSID-CDS, and in primary sampling units in the NHANES, using SVY commands in Stata 11. We report 95% confidence intervals (henceforth CI). Analyses were determined to be exempt from human subjects review by the RAND Human Subject Protection Committee.

RESULTS

True obesity prevalence was estimated from the NHANES to be 11.0% (CI: 9.7, 12.3%) at ages 2-5 and 17.5% (CI: 16.1, 18.9%) at ages 6-13 (Table 1). Against this standard,

obesity prevalence in the NLSY and PSID was greatly overestimated at ages 2-5 (NLSY 19.9%, CI: 18.4, 21.5%; PSID 27.2%, CI: 23.4, 31.0%), but accurately estimated at ages 6-13 (NLSY 16.0%, CI: 14.9, 17.1%; PSID 16.0%, CI: 13.7, 18.4%). At ages 2-5, NLSY and PSID obesity prevalence exceeded NHANES prevalence most for children with parent-reported height and weight (NLSY 32.3%, CI: 29.2, 35.5%; PSID-CDS-I 36.6%, CI: 30.7, 42.5%) and least for children with measured height and weight (NLSY 13.8%, CI: 12.0, 15.7%). Additional age-breakdowns possible for NLSY children with parent-reported weight and height reveal that, compared to NHANES children, their obesity prevalence was 6.4 percentage points higher at age 6-8, not statistically different at age 9-11, and 5.8 percentage points lower at ages 12-13.

[TABLE 1 ABOUT HERE]

The overestimation of obesity prevalence seen in Table 1 in the parent-reported subsamples of NLSY and PSID children ages 2-5 could have resulted from either (or both) parents over-reporting weight or under-reporting height. Comparisons of the proportions of NLSY and PSID children in the 20 upper-most percentiles of weight-for-age (Figure 1) and in the 20 lower-most percentiles of height-for-age (Figure 2) relative to NHANES children indicate that under-reporting of height predominated. Whereas just under 1% of children in the NHANES fell below the 1st percentile (0.8%), an implausibly high 13.6% and 21.0%, respectively, of NLSY and PSID children with parent-reported height did so. By comparison, the proportion of NLSY and PSID children above the 99th weight percentile was only about 1 percentage point greater than in the NHANES.

[FIGURES 1 AND 2 ABOUT HERE]

Analogously, a pattern of either (or both) under-reporting of weight or over-reporting of height could have produced the NLSY underestimation of obesity for parent-reported children ages 12-13. Considering the upper-most values of weight-for-age (Figure 3) and of height-for-age (Figure 4), we find that parents both under-reported weight and over-reported height. The percentage of NLSY children age 12-13 with reported weight above the 99th weight-for-age percentile was about 2 percentage points less than in the NHANES. Similarly, the percentage of NLSY children with reported height above the 99th percentile was almost 2 percentage points greater than in the NHANES.

[FIGURE 3 AND FIGURE 4 ABOUT HERE]

The NLSY 2006 and 2008 subsample with both parent-reported and measured weight and height had too few age 2-5 children for separate analysis. For children ages 2-8, however, parent-reported height was on average 2.1 inches lower than measured height at the same assessment, and for children ages 9-11 and 12-13 respectively 1.6 inches and 1.1 inches lower (Table 2). Parent-reported weight bias, in contrast, widened with increasing child age, from being on average 35.5 ounces lower at ages 2-8 to 136.2 ounces lower at ages 12-13. The height and weight bias observed in this subsample reinforced both the direction and age pattern of results previously described.

[TABLE 2 ABOUT HERE]

We next examined the obesity prevalence of children with very low height in the NLSY, PSID, and NHANES (Figure 4). We learned from the NHANES that obesity was quite rare among children with very short stature, so rare that children below the 5th percentile height-for-age had to be pooled to obtain reliable estimates, which were 4.0% obese at ages 2-5 and 2.5% obese at ages 6-13. In contrast, among NLSY and PSID children with parent-reported height below the 1st percentile, obesity prevalence was entirely implausible at 88.5% and 89.0% at ages 2-5, and 50.3% and 59.5% at ages 6-13. Erroneous parental reporting of very low height is clearly indicated. We note also, however, that obesity prevalence among children with *measured* height below the 1st percentile in both the NLSY and PSID was almost as high, implying erroneous height measurement. The measuring and recording of height by survey staff or parents following the panel survey protocols was apparently substantially less accurate than the measuring and recording by medical professionals in the NHANES using specialized data recording software.

[FIGURE 5 ABOUT HERE]

Contributions of height and weight error in the NLSY and PSID to these panel survey's estimates of obesity prevalence are quantified in Table 3, for the subsamples considered above in Table 1. Error in reporting height below the 1st percentile again dominates for children ages 2-5: substituting NHANES values for NLSY and PSID values (Substitution 1), we found that bias induced by height error below the 1st percentile constituted about half of the total upward bias (5.2 of the overall 9.0 percentage-point bias in the NLSY and 8.2 of the overall 16.3 percentage-point bias in the PSID). Bias induced by height error below the 1st percentile was largest in the *parent-reported* height and weight subsamples of the NLSY and PSID: estimated obesity prevalence bias was 11.5 and 13.7 percentage points respectively. Substituting NHANES values up to the 2nd and then 5th percentiles of height-for-age showed only small additional increases in estimated bias (Substitutions 2 and 3). Substituting NHANES values for parent-reported weight-for-age above the 99th, 98th, and then 95th percentiles (Substitutions 4-6), however, showed that very little bias was induced in the panel surveys due to error in very high weights at ages 2-5.

[TABLE 3 ABOUT HERE]

Among children age 6-13 with parent-reported height and weight, an upward bias of 5.9 percentage points was estimated by substituting NHANES for PSID height values below the 1st percentile, and among NLSY children age 6-8, a 5.5 percentage-point upward bias in obesity prevalence was estimated. Little bias was induced by error in height below the 1st percentile for NLSY children at ages 9-11 and 12-13.

In contrast with the age pattern of (upward) bias in obesity prevalence contributed by parent reporting of low values of height, (downward) bias in obesity prevalence contributed by error in parent reporting of very high values of weight was greater at

older child ages (see Substitutions 4-6). Substituting NHANES values of weight-for-age for parent-reported weight-for-age above the 95th percentile increased obesity prevalence by 5.7 percentage points for children ages 6-13 in the PSID, and by 2.2, 4.0, and 5.3 percentage points in the NLSY at ages 6-8, 9-11, and 12-13. This latter substitution, for NLSY children aged 12-13 with parent-reported height and weight, constituted almost all (91%) of the 5.8 percentage-point bias in this subsample.

DISCUSSION

Our findings are broadly consistent with previous evidence on bias in estimates of obesity from nationally-representative samples of U.S. children. Obesity prevalence estimated from parent-reported height and weight from the 1999-2004 National Health Interview Survey and the 2003-2004 National Survey of Children's Health (NSCH) was nearly five times as high as in the measured NHANES at ages 2-3 and about 2.7 times at ages 4-5, and this bias was found to diminish rapidly with increasing age, reversing to underestimating obesity prevalence after ages 12-13(7). The NSCH no longer releases parent-reported height or calculated BMI for children under age 10(45). Similarily, in a previous analysis of parent-reported data in the 1998 NLSY the prevalence was overestimated by 4 to 7 times at ages 2, 3, and 4 but not at all by age 10(8). On the basis of larger observed differences in mean height than mean weight between the parent-reported versus measured samples, both of these studies speculated that height under-reporting rather than weight over-reporting accounted for overestimation of obesity at young ages(7,8). Our study provides strong empirical support for this speculation. Similarly, our study shows that parental under-reporting of weight is quantitatively important for underestimation of obesity at older child ages.

In contrast with our findings and the two previously noted studies employing nationally-representative U.S. samples, other studies had been inconsistent as to whether height is under-reported(13,19,21), over-reported(14,15), or either under- and over-reported by parents depending on the child's age and gender(18). Additionally, although most studies have observed that weight was under-reported(13,16-19,21) rather than over-reported(15) or accurately reported (14), relatively few have observed notable reporting error for height(13,14,19). We speculate that inconsistencies in the findings across these studies and in comparison to our own may be driven by limitations in the generalizability of the samples with respect to nationality and age. The majority of these studies were conducted in Canada or Western Europe. The use of the metric system in those countries, contrasted with the imperial measurement system of the United States, may lead to different types of recall error.

In addition, as in several of the preceding studies(7,8,13,17,18), we observe that under-reporting of height decreases with age, but that under-reporting of weight increases with age. Parents' recall of children's heights apparently becomes more quickly out of date for young, rapidly-growing children. Not only is recall error on height compounded through its being squared in the calculation of BMI, but our study and others(7,8,13,14) also find that parents are more likely to track children's weight than height accurately at these ages. The greater under-reporting of weight among parents of the heaviest older

children that we observe has previously been attributed both to social desirability bias and to actual misperceptions(23,26-28).

Based on our findings, we especially caution researchers using parent-reported data for very young children, but note that by around ages 8 to 9 parent-reported data become reasonably accurate. One practical solution for child obesity researchers who only have parent-reported data available on young children is that they consider analyzing weight-for-age which is generally accurately reported, instead of BMI, which is subject to major bias contributed by mis-reported height that is exacerbated by the squaring of height in the BMI calculation. To survey data producers, we suggest that in cases where child measurement is practically or financially impossible, survey collection efforts focus on improving the quality of height assessments more than of weight assessments. For example, one recent study(20) reported achieving substantially improved data from parents by simply asking them to measure their children before a scheduled telephone interview.

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Table 1. Obesity Prevalence and Obesity Prevalence Bias in the Children of the NLSY-Child, 1996-2008, and PSID-CDS, 1997 and 2002/3, Respective to the NHANES, 1999-2008, by Age-group[a]

	Observations	Prevalence		Bias	
		%	95% CI	(Survey % - NHANES %)	95% CI
Age 2-5					
NHANES	4,145	11.0	9.7, 12.3		
NLSY-Child, total	4,085	19.9	18.4, 21.5	9.0	7.0, 11.0
NLSY-Child, measured weight & height	2,268	13.8	12.0, 15.7	2.9	0.6, 5.1
NLSY-Child, reported weight, measured height	464	15.7	12.0, 19.4	4.7	0.8, 8.6
NLSY-Child, measured weight, reported height	101	25.3	16.1, 34.4	14.3	5.0, 23.6
NLSY-Child, reported weight & height	1,252	32.3	29.2, 35.5	21.4	18.0, 24.8
PSID-CDS-I, total	1,026	27.2	23.4, 31.0	16.3	12.3, 20.3
PSID-CDS-I, reported weight, measured height	620	20.5	16.3, 24.8	9.6	5.1, 14.1
PSID-CDS-I, reported weight & height	406	36.6	30.7, 42.5	25.6	19.6, 31.7
Age 6-13					
NHANES	8,136	17.5	16.1, 18.9		
NLSY-Child, total	15,045	16.0	14.9, 17.1	-1.5	-3.3, 0.3
NLSY-Child, measured weight & height	9,546	15.5	14.2, 16.7	-2.0	-3.9, -0.2
NLSY-Child, reported weight, measured height	1,186	15.2	12.6, 17.9	-2.3	-5.3, 0.7
NLSY-Child, measured weight, reported height	795	19.5	16.3, 22.7	2.0	-1.5, 5.5
NLSY-Child, reported weight & height	3,518	16.9	15.1, 18.6	-0.7	-3.0, 1.6
PSID-CDS-I, total	1,772	16.0	13.7, 18.4	-1.5	-4.2, 1.3
PSID-CDS-I, reported weight, measured height	1,409	15.0	12.4, 17.6	-2.5	-5.5, 0.5
PSID-CDS-I, reported weight & height	363	20.2	14.6, 25.8	2.7	-3.1, 8.4
PSID-CDS-II, total (measured weight & height)	1,631	20.0	17.2, 22.9	2.5	-0.7, 5.7
Age 6-8					
NHANES	2,781	15.2	13.6, 16.9		
NLSY-Child, total [b]	4,684	15.4	14.0, 16.8	0.2	-1.9, 2.3
NLSY-Child, measured weight & height	3,279	13.5	11.9, 15.0	-1.8	-4.0, 0.4
NLSY-Child, reported weight & height	812	21.6	18.1, 25.1	6.4	2.5, 10.3

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Table 1. (Continued)

	Observations	Prevalence		Bias	
		%	95% CI	(Survey % - NHANES %)	95% CI
Age 9-11					
NHANES	2,725	19.2	17.2, 21.1		
NLSY-Child, total [b]	5,983	16.8	15.4, 18.1	-2.4	-4.8, 0.0
NLSY-Child, measured weight & height	3,895	16.1	14.6, 17.7	-3.0	-5.5, -0.5
NLSY-Child, reported-weight & height	1,283	18.4	15.7, 21.1	-0.8	-4.2, 2.5
Age 12-13					
NHANES	2,630	18.6	16.1, 21.0		
NLSY-Child, total [b]	4,378	15.6	14.2, 17.0	-3.0	-5.8, -0.2
NLSY-Child, measured weight & height	2,372	17.2	15.3, 19.1	-1.3	-4.4, 1.8
NLSY-Child, reported-weight & height	1,423	12.8	10.8, 14.8	-5.8	-8.9, -2.6

Abbreviations: NHANES, National Health and Nutrition Examination Surveys; NLSY-Child, National Longitudinal Survey of Youth; PSID-CDS-I, Panel Study of Income Dynamics, Child Development Supplement, Wave I; PSID-CDS-II, Panel Study of Income Dynamics, Child Development Supplement, Wave II; CI, confidence interval.

[a] Bias is calculated by subtracting the NHANES obesity prevalence from the obesity prevalence in the panel survey sample. Percentages are weighted using sample weights for the respective surveys. Confidence interval estimates adjust for stratification and clustering in the NHANES sample design, and for clustering in the NLSY-Child and PSID-CDS sample designs.

[b] The NLSY-Child total for ages 6-8, 9-11, and 12-13 includes two subsamples with insufficient sample sizes to be shown separately: children with reported weight and measured height, and children with measured weight and reported height.

Table 2. Bias in Mother-reported Heights, Mother-reported Weights, and Calculated BMI in the NLSY-Child, 2006 and 2008[a]

		BMI		Height in inches (Height in cm)		Weight in ounces (Weight in kg)	
Age	Observations	Mean Bias	95% CI	Mean Bias	95% CI	Mean Bias	95% CI
2-8	337	1.5	0.8, 2.2	-2.1	-2.8, -1.3	-35.5	-54.1, -16.8
				(-5.2)	(-7.1, -3.4)	(-1.0)	(-1.5, -0.5)
9-11	415	0.1	-0.4, 0.5	-1.6	-2.1, -1.2	-98.9	-127.3, -70.5
				(-4.1)	(-5.31, -2.93)	(-2.8)	(-3.6, -2.0)
12-13	350	-0.6	-1.1, -0.2	-1.1	-1.5, -0.7	-136.2	-166.3, -106.1
				-2.9	(-3.9, -1.8)	(-3.9)	(-4.7, -3.0)

Abbreviations: NLSY-Child, National Longitudinal Survey of Youth; cm, centimeters; kg, kilograms; CI, confidence interval.

[a]Bias is calculated by subtracting the measured observation from the mother-reported observation for each survey wave the child is assessed with both a measured and mother-reported weight and height assessment. Data are weighted using survey sample weights, and confidence interval estimates adjust for clustering of children in families.

Table 3. Total Observed Obesity Prevalence Bias and Estimated Obesity Prevalence Bias Induced by Parent-Reported or Measured Very Low Height or Very High Weight, by Age-Group, NLSY-Child, 1996-2008, and PSID-CDS, 1997 and 2002/3, Compared with the NHANES, 1999-2008[a]

		Estimated Bias Induced by Mis-Measurement or Mis-Reporting of Very High Weight or Very Low Weight					
		Substitute NHANES Height-for-Age[c]			Substitute NHANES Weight-for-Age[d]		
	Total Observed Bias[b]	(1) Substitute <1st Percentile Height	(2) Substitute <2nd Percentile Height	(3) Substitute <5th Percentile Height	(4) Substitute >99th Percentile Weight	(5) Substitute >98th Percentile Weight	(6) Substitute >95th Percentile Weight
Age 2-5							
NLSY-Child, total	9.0	5.2	6.0	6.7	0.1	0.0	0.3
NLSY-Child, measured weight & height	2.9	1.5	1.7	2.0	-0.2	-0.3	0.1
NLSY-Child, reported weight, measured height	4.7	3.9	4.2	4.9	-0.1	-0.1	-0.8
NLSY-Child, measured weight, reported height	14.3	6.7	9.5	11.3	1.6	0.0	1.3
NLSY-Child, reported weight & height	21.4	11.5	13.4	14.9	0.5	0.4	0.7
PSID-CDS-I, total	16.3	8.2	9.3	10.8	0.2	0.2	1.9
PSID-CDS-I, reported weight, measured height	9.6	3.9	5.0	6.8	0.1	-0.6	0.6
PSID-CDS-I, reported weight & height	25.6	13.7	14.7	15.4	0.3	1.0	3.1
Age 6-13							
NLSY-Child, total	-1.5	1.0	1.1	1.4	-0.8	-1.6	-2.7
NLSY-Child, measured weight & height	-2.0	0.5	0.5	0.8	-0.8	-1.6	-2.5
NLSY-Child, reported weight, measured height	-2.3	0.4	0.4	0.7	-0.4	-1.1	-2.1
NLSY-Child, measured weight, reported height	2.0	2.8	3.1	3.4	0.3	-0.9	-1.5
NLSY-Child, reported weight & height	-0.7	2.2	2.6	2.8	-1.1	-1.9	-3.7

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Table 3. Continued

	Total Observed Bias[b]	Estimated Bias Induced by Mis-Measurement or Mis-Reporting of Very High Weight or Very Low Weight[c]					
		Substitute NHANES Height-for-Age			Substitute NHANES Weight-for-Age		
		(1)	(2)	(3)	(4)	(5)	(6)
Age 6-13 (Continued)							
PSID-CDS-I, total	-1.5	3.2	3.6	4.0	-2.3	-3.8	-5.9
PSID-CDS-I, reported weight, measured height	-2.5	2.5	2.8	3.0	-2.2	-3.6	-6.0
PSID-CDS-I, reported weight & height	2.7	5.9	6.9	7.9	-2.6	-4.4	-5.7
PSID-CDS-II, total (measured weight & height)	2.5	0.3	0.5	0.8	1.7	1.9	1.5
Age 6-8							
NLSY-Child, total[d]	0.2	2.1	2.3	2.7	-0.8	-1.1	-2.3
NLSY-Child, measured weight & height	-1.8	0.8	0.9	1.3	-1.2	-1.3	-2.4
NLSY-Child, reported weight & height	6.4	5.5	6.1	6.7	0.2	-0.7	-2.2
Age 9-11							
NLSY-Child, total[d]	-2.4	0.6	0.7	1.0	-1.0	-2.0	-3.7
NLSY-Child, measured weight & height	-3.0	0.2	0.3	0.4	-1.1	-2.2	-3.7
NLSY-Child, reported weight & height	-0.8	1.6	2.2	2.5	-1.0	-1.8	-4.0
Age 12-13							
NLSY-Child, total[d]	-3.0	0.4	0.5	0.6	-0.6	-2.1	-2.6
NLSY-Child, measured weight & height	-1.3	0.4	0.4	0.6	0.2	-1.2	-1.2
NLSY-Child, reported weight & height	-5.8	0.6	0.8	0.7	-2.3	-3.7	-5.3

Abbreviations: NHANES, National Health and Nutrition Examination Surveys; NLSY-Child, National Longitudinal Survey of Youth; PSID-CDS-I, Panel Study of Income Dynamics, Child Development Supplement, Wave I; PSID-CDS-II, Panel Study of Income Dynamics, Child Development Supplement, Wave II.

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Table 3. Footnotes Continued

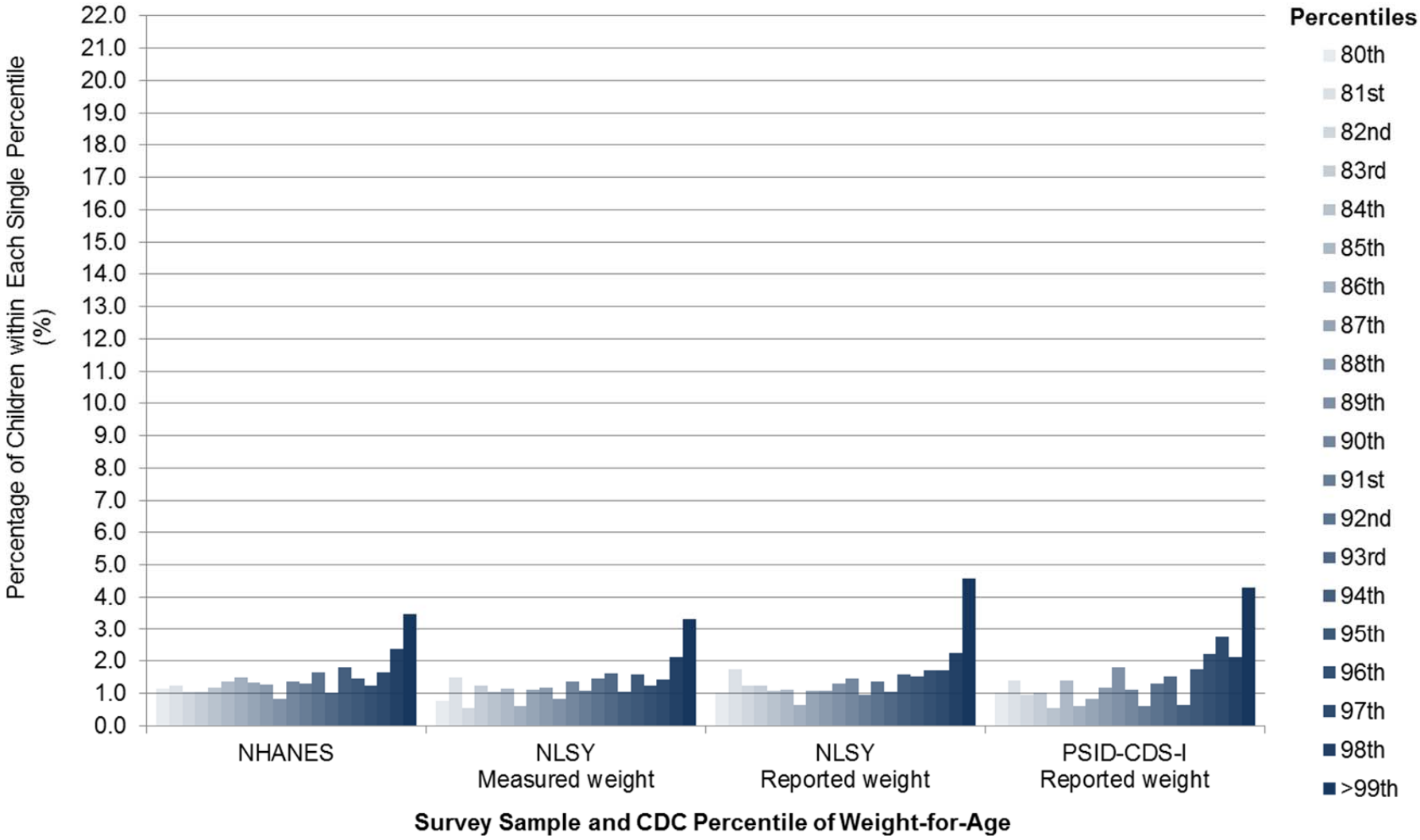
[a] Percentages are weighted using sample weights for the respective surveys.

[b]Total observed bias is calculated by subtracting the NHANES obesity prevalence from the obesity prevalence observed in the panel survey. These figures are reported in Table 1.

[c]Estimated bias is calculated by subtracting the expected obesity prevalence in the panel survey from the observed obesity prevalence in the panel survey, where the expected obesity prevalence is obtained after removing bias in weights or heights below the specified percentile through substitution of NHANES values. Substitutions are of both the NHANES percentage of cases below a given height-for-age or weight-for-age percentile and the % obese among those with height below that percentile or with weight above that percentile. Because of small samples sizes of children in the NHANES with height below the <1st and <2nd percentiles, simulation 1 and simulation 2 employ the % obese among NHANES children with height <5th percentile.

[d] The NLSY-Child total for ages 6-8, 9-11, and 12-13 includes two subsamples with insufficient sample sizes to be shown separately: children with reported weight and measured height, and children with measured weight and reported height.

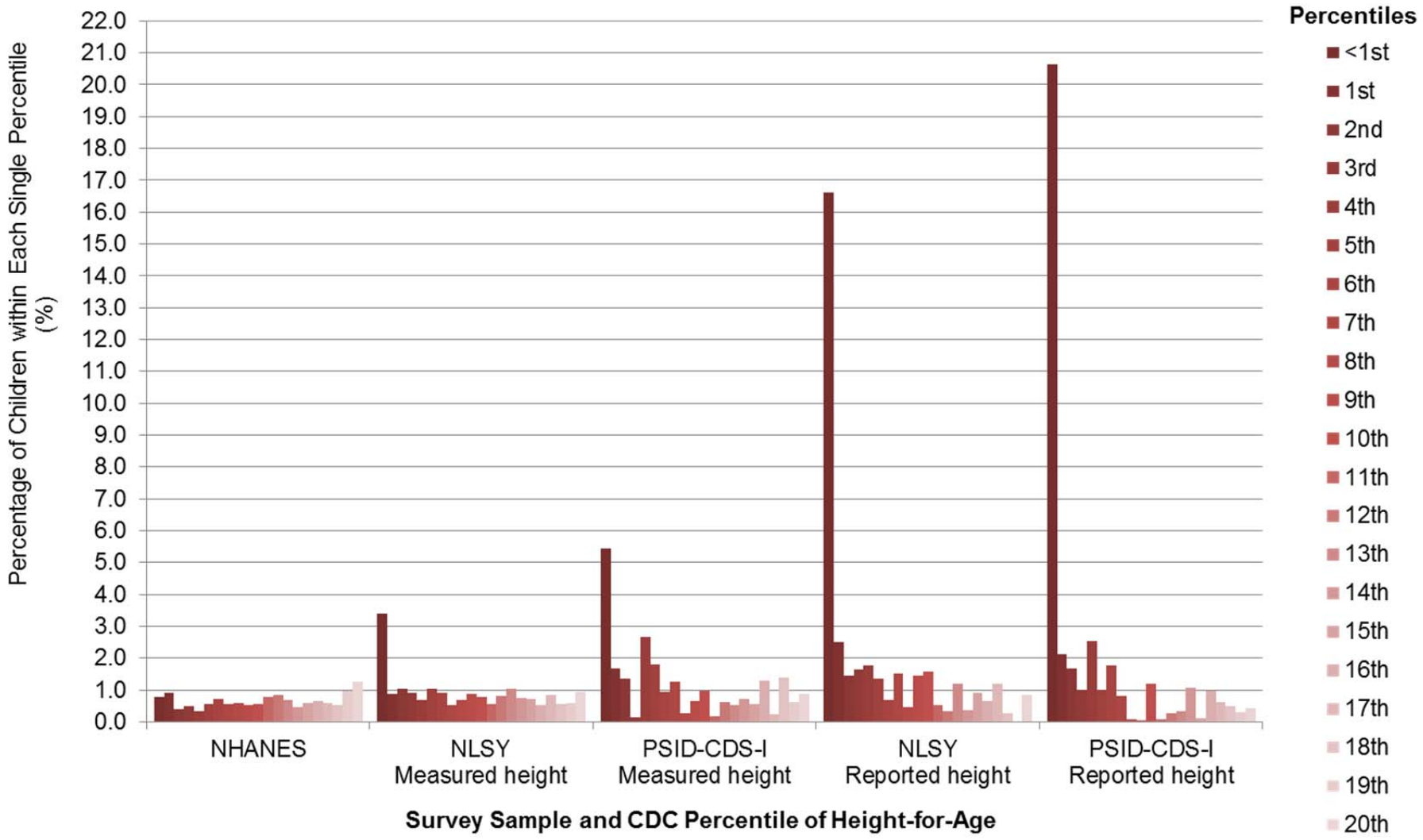
Figure 1. Percentages of U.S. Children Age 2 to 5 within Each of the Top Twenty Percentiles of Weight-for-Age[a]



Abbreviations: NHANES, National Health and Nutrition Examination Surveys 1999-2008; NLSY, Children of the National Longitudinal Survey of Youth, 1996-2008; PSID-CDS-I, Panel Study of Income Dynamics Child Development Supplement, Wave I, 1997.

[a]Percentages are weighted using respective survey sample weights.

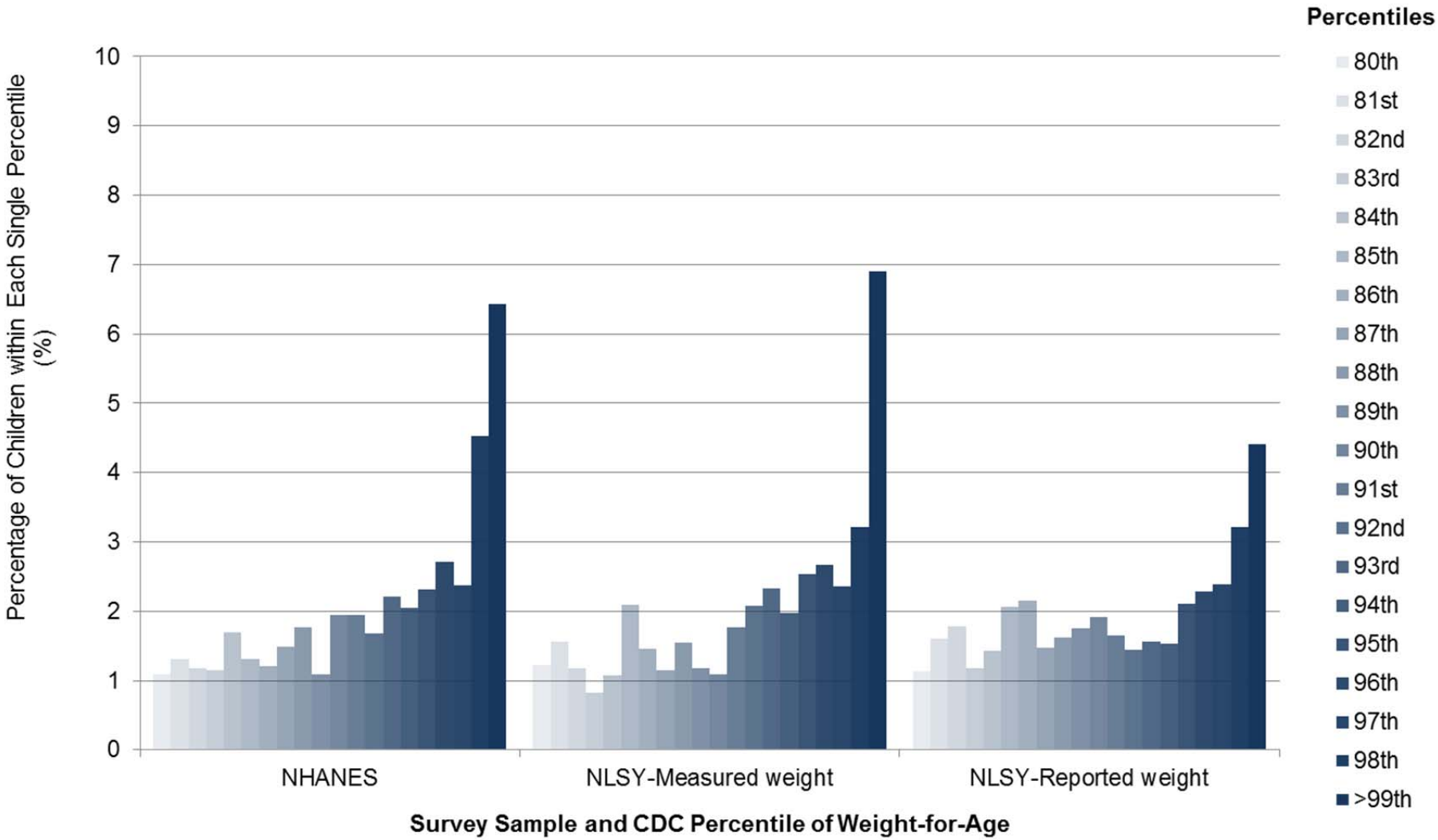
Figure 2. Percentages of U.S. Children Age 2 to 5 within Each of the Bottom Twenty Percentiles of Height-for-Age[a]



Abbreviations: NHANES, National Health and Nutrition Examination Surveys 1999-2008, NLSY, Children of the National Longitudinal Survey of Youth, 1996-2008; PSID-CDS-I, Panel Study of Income Dynamics Child Development Supplement, Wave I, 1997.

[a]Percentages are weighted using respective survey sample weights.

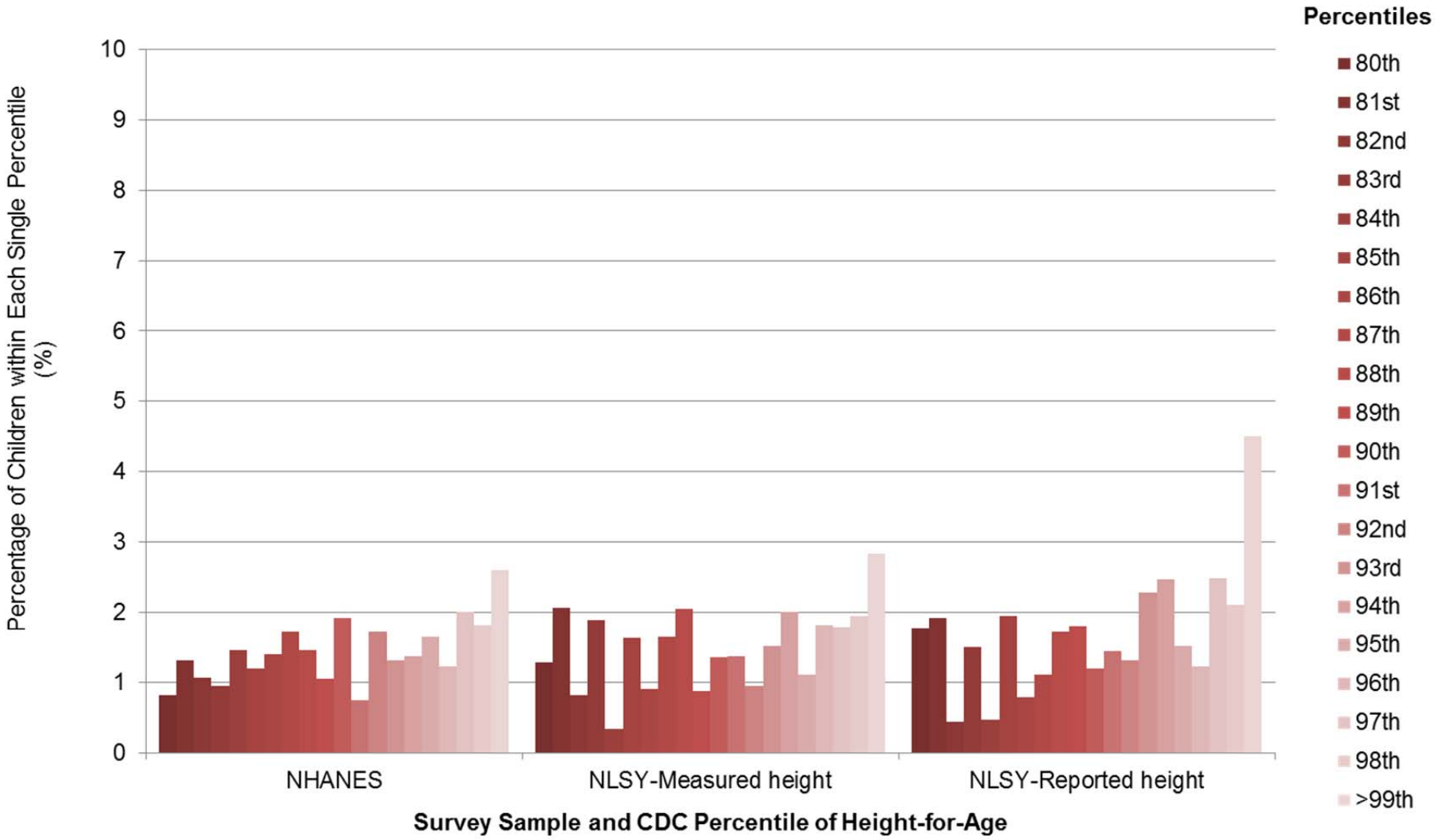
Figure 3. Percentages of U.S. Children Age 12 to 13 within Each of the Top Twenty Percentiles of Weight-for-Age



Abbreviations: NHANES, National Health and Nutrition Examination Surveys, 1999-2008; NLSY, Children of the National Longitudinal Survey of Youth, 1996-2008.

[a]Percentages are weighted using respective survey sample weights.

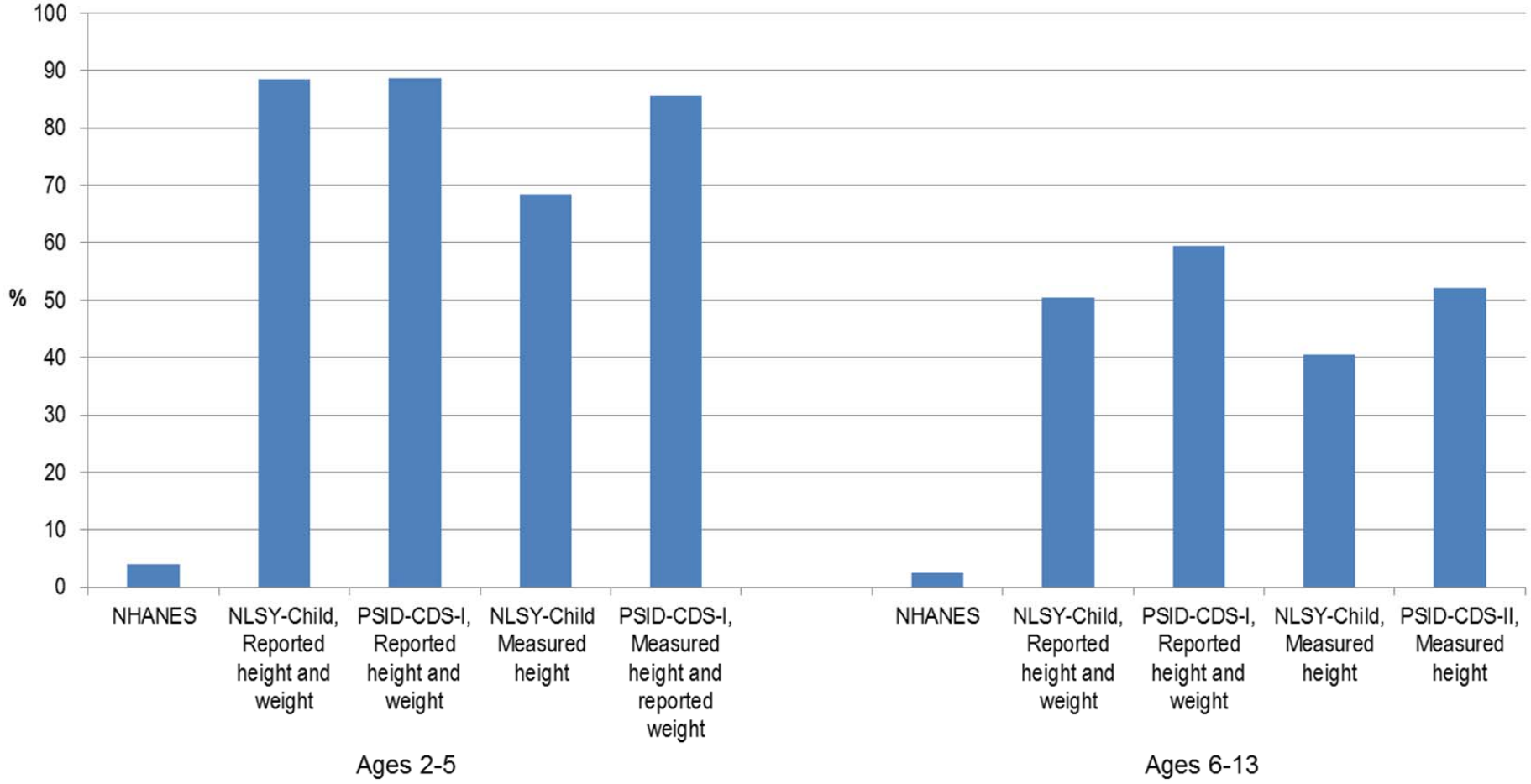
Figure 4. Percentages of U.S. Children Age 12 to 13 within Each of the Top Twenty Percentiles of Height-for-Age



Abbreviations: NHANES, National Health and Nutrition Examination Surveys, 1999-2008; NLSY, Children of the National Longitudinal Survey of Youth, 1996-2008.

[a]Percentages are weighted using respective survey sample weights.

Figure 5. Obesity Prevalence of Children in NLSY-Child and PSID-CDS <1st Percentile Height-for-Age and NHANES <5th Percentile Height-for-Age, by Age Group and Parent-reported versus Measured Height[a]



Abbreviations: NHANES, National Health and Nutrition Examination Surveys, 1999-2008; NLSY-Child, Children of the National Longitudinal Survey of Youth, 1996-2008; PSID-CDS-I, PSID-CDS-II, Panel Study of Income Dynamics Child Development Supplement, Wave I, 1997, and Wave II, 2002/3

[a] We do not report data for NLSY-Child with reported height and measured weight. Percentages are weighted using respective survey sample weights. In the NHANES, because there are few children with height below the CDC 1st percentile, the conditional prevalence of obesity is among children with height below the CDC 5th percentile.

Appendix Table 1. Demographic and Socioeconomic Characteristics of the Measured and Parent-reported Components of the NLSY and PSID CDS-I Survey Samples[a]

	Children of the National Longitudinal Survey of Youth, 1996-2008							
	Measured weight & height		Measured weight, reported height		Reported weight, measured height		Reported weight & height	
	% or mean	95% CI	% or mean	95% CI	% or mean	95% CI	% or mean	95% CI
Female	48.6	46.9, 50.4	47.1	42.5, 51.6	53.7	50.2, 57.1	47.8	45.4, 50.2
Year	2000.2	2000.1, 2000.4	2000.9	2000.5, 2001.3	2000.7	2000.4, 2001.0	2000.8	2000.6, 2000.9
Mother's age at child's birth (years)	29.8	29.6, 30.0	29.5	29.0, 30.0	30.9	30.5, 31.2	30.3	30.0, 30.5
Race/ethnicity[b]								
Non-Hispanic White	77.6	75.7, 79.5	80.1	77.0, 83.1	81.6	78.9, 84.3	79.4	77.3, 81.4
Hispanic	7.4	6.4, 8.4	6.4	4.9, 7.9	7.6	6.2, 9.1	7.7	6.6, 8.8
Non-Hispanic Black	13.5	12.0, 15.0	12.6	10.3, 15.0	8.5	6.5, 10.4	10.4	9.1, 11.7
Non-Hispanic Other	1.5	0.8, 2.2	0.9	0.1, 1.7	2.4	1.2, 3.6	2.5	1.4, 3.7
Family income[c]								
< 25,000	21.4	19.6, 23.2	22.9	18.9, 26.8	18.5	15.5, 21.4	18.9	16.9, 21.0
25,000-49,000	25.5	23.6, 27.4	22.0	18.0, 26.0	22.7	19.5, 25.9	21.5	19.4, 23.7
50,000-74,000	23.2	21.4, 24.9	22.3	18.2, 26.4	25.2	21.9, 28.5	25.0	22.6, 27.4
75,000-99,000	14.5	13.0, 16.1	16.6	12.7, 20.5	15.9	12.8, 19.0	16.2	14.2, 18.2
≥ 100,000	15.4	13.5, 17.4	16.2	12.1, 20.4	17.8	14.6, 21.0	18.3	15.8, 20.9
Total (mean)	69,303	65,211	72,564	56,182	77,527	68,772	78,262	71,995
Observations (person-years)	10,127		758		1,401		3,915	

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Appendix Table 1. Continued

	Panel Study of Income Dynamics, Child Development Supplement, Wave 1, 1997			
	Measured weight & height		Measured weight, reported height	
	% or mean	95% CI	% or mean	95% CI
Female	49.7	46.6, 52.9	51.1	46.4, 55.8
Year	1997		1997	
Mother's age at child's birth (years)	27.3	26.9, 27.7	27.1	26.5, 27.6
Race/ethnicity[b]				
Non-Hispanic White	66.3	62.6, 70.0	66.5	61.6, 71.3
Hispanic	9.3	6.9, 11.6	14.9	10.6, 19.2
Non-Hispanic Black	16.8	14.1, 19.5	12.7	10.1, 15.3
Non-Hispanic Other	7.6	5.3, 9.9	6.0	3.6, 8.4
Family income[c]				
< 25,000	25.5	22.0, 29.0	24.4	19.8, 29.1
25,000-49,000	29.8	26.4, 33.2	33.3	28.4, 38.3
50,000-74,000	20.9	17.9, 23.8	18.6	14.3, 22.9
75,000-99,000	12.0	9.5, 14.5	12.2	8.6, 15.9
≥ 100,000	11.7	9.5, 14.0	11.4	7.8, 15.0
Total (mean, dollars)	58,072	53,061	53,467	49,052
Observations (persons)	1,885		731	

Abbreviations: CI, confidence interval.

[a] Means and percentages are weighted using sample weights for the respective surveys. Confidence interval estimates adjust for clustering in the NLSY-Child and PSID-CDS sample designs. Samples exclude observations with missing data on any of the socioeconomic or demographic characteristics.

[b]Race/ethnicity is of mother in NLSY and race/ethnicity is of child in CDS.

[c]Family income is adjusted to 2000 dollars.