Supplementary Online Content

Madsen KA, Thompson HR, Linchey J, et al. Effect of school-based body mass index reporting in California public schools: a randomized clinical trial. *JAMA Pediatr*. Published online November 16, 2020. doi:10.1001/jamapediatrics.2020.4768

This supplementary material has been provided by the authors to give readers additional information about their work.

eAppendix

1. Physiologically implausible BMI values

Students' height and weight measurements were used to calculate their BMI, defined as weight in kilograms divided by height in meters squared. Z-scores for height, weight, and BMI were calculated according to the 2000 CDC Growth Reference chart with Stata package zanthro (version dm0004_1)[1] using each student's sex, age (in years), and measured height, weight, or BMI, respectively. Height, weight, and BMI z-scores were converted into percentiles based on a standard Normal distribution.

For each strata of age in years (range 8 to 14), we calculated the median, 25th percentile, 75th percentile and interquartile range for both height and weight. A student's BMI was considered physiologically improbable and excluded if:

a) height or weight was below the 25th percentile of height/weight less three times the interquartile range for height/weight or above the 75th percentile plus three times the interquartile range for height/weight
b) height or weight change was below the 25th percentile of height/weight change less three times the interquartile range for height/weight change or above the 75th percentile plus three times the interquartile range for height/weight change
c) the absolute value of height or weight z-score was greater than or equal to 5
d) BMI z-score was less than -5

2. Multiple imputation

For students with valid baseline BMI values, missing follow-up BMI, height, and weight measurements were estimated using multiple imputation by chained equations (MICE) in 25 imputed datasets; variables used in imputation included baseline BMI, baseline height, baseline weight, age, sex, race, district, school, grade, school-level FRPM, and calendar year. MICE was performed using the MI suite of commands in Stata.[2] Imputation was performed separately on the intervention (BMI reporting) and control (BMI screening) groups using the command mi impute with the 'by' option. Values were imputed using truncated regressions,[3] where the lower and upper bounds for truncation were set equal to the minimum and maximum observed BMI, height, and weight values in the sample, respectively.

Linear mixed effects models that included a group by time interaction term and random intercepts for school and student were estimated on the 25 multiply imputed datasets with the mi estimate command in Stata's mi suite. As in the complete-case analyses, the outcome of interest in these models was student BMI z-score, and we adjusted for sex, race, district, grade, school-level percentage of students eligible for free-and-reduced price (FRPM) meals, and calendar year. Effect modification by ethnicity (Hispanic vs. non-Hispanic) and elementary grade status (grades 3 to 5 at baseline vs. grades 6-7 at baseline) was explored in separate mixed effect models also estimated using the multiply imputed data. Stata package mimrgns was used to obtain adjusted predictions following estimation of regression models on multiply imputed BMI data.

3. Student survey items

Outcome	Question	Response scale
Peer weight-teasing index	I am teased or made fun of at school because of my weight. Other kids are teased at school because of their weight.	5-pt scale from *Never* to *Almost every day*
Peer weight talk	How often do kids at your school talk about weight, weight loss or dieting?	
Teacher weight talk	Teachers talk about my weight or size.	
Body satisfaction	How happy are you with your height? How happy are you with your weight? How happy are you with your body shape? How happy are you with your body build?	5-pt scale from *Very unhappy* to *Very happy*
Concerning weight-control behaviors index	Have you done any of the following things in order to lose weight or keep from gaining weight during the past year? • Ate very little food • Skipped meals Have you gone on a diet during the last year? (By "diet" we mean changing the way you eat so you can lose weight.)	Yes/No
Family weight-talk index	My family talks about my weight or size. My family says things about my weight or size that make me feel bad.	5-pt scale from *Never* to *Almost every day*
Family weight teasing	My family teases or makes fun of me because of my weight.	
Family encouraging dieting	My family encourages me to diet to control my weight.	4-pt scale from *Not at all* to *Very much*

4. Body satisfaction

Drawing on the body satisfaction instrument used in the Project EAT study,[4] the student survey asked how happy students were with their weight, height, body shape, and body build, on a 5-point scale from "Very unhappy" to "Very happy." Body satisfaction was calculated as the mean of the 4 items. During survey administration elementary students frequently asked questions about the meaning of "body shape" and "body build," and across years, the response for satisfaction with body build was twice as likely to be missing as the response for satisfaction with weight ($p<0.001$). Therefore, to minimize bias related to dropping students with missing values, weight satisfaction was used as the primary outcome. Results were similar for the outcomes of body satisfaction and weight satisfaction, as shown below.

Adjusted weight stigmatization outcomes

				1-yr change			2-year change		
	Baseline	1 Year	2 Year	Within-Group	Between-Group	P Value[B]	Within-Group	Between-Group	P Value[B]
Child and peer-based outcomes: BMI Reporting and BMI Screening groups combined vs. Control group									
Weight satisfaction (range 1 to 5), **N=14318**									
BMI Reporting & BMI Screening	3.43±0.02	3.45±0.02	3.36±0.03	0.01 [-0.03,0.06]	-0.03 [A] [-0.07,0.01]	0.14	-0.07 [-0.15,0.01]	-0.11 [A] [-0.18,-0.05]	0.001
Control	3.41±0.02	3.46±0.02	3.46±0.04	0.04 [-0.01,0.09]			0.04 [-0.05,0.13]		
Body satisfaction (range 1 to 5), **N=14029**									
BMI Reporting & BMI Screening	3.65±0.02	3.66±0.01	3.59±0.02	0.01 [-0.02,0.05]	-0.01 [A] [-0.04,0.02]	0.43	-0.06 [-0.13,0.00]	-0.08 [A] [-0.13,-0.03]	0.001
Control	3.64±0.02	3.66±0.02	3.66±0.03	0.02 [-0.02,0.06]			0.02 [-0.05,0.09]		

Plus–minus values are estimated marginal means±SE

[A] Between-group difference: BMI Reporting and BMI Screening groups combined minus Control group.

5. Analyses with additional categories of race/ethnicity as effect modifiers

We additionally explored race as an effect modifier in models comparing non-Hispanic white students to all others, non-Hispanic black students to all others, non-Hispanic Asian students to all others, Hispanic students to non-Hispanic white students, and non-Hispanic black students to non-Hispanic white students. P-values for overall test of effect modification of group by time interaction by additional race/ethnicity categories were as follows:

- Non-Hispanic White vs. all others 0.26
- Non-Hispanic Black vs. all others 0.81
- Non-Hispanic Asian vs. all others 0.097
- Hispanic vs. non-Hispanic White 0.16
- Non-Hispanic Black vs. non-Hispanic White 0.67

6. Timing of BMI Reports

California schools are required to conduct BMI assessments and fitness testing between February and April of each year and to submit data to the California Department of Education (CDE) by early May. Like the CDE, we received BMI data from schools by the end of May, and data processing and report preparation took approximately 8 weeks. Rather than send reports over the summer, when families might be traveling, we elected to send them as soon as school was back in session. This led to an approximate 6-9 month lag, with a range of 5 to 10 months. To determine if the time lag might decrease the salience of reports for parents, we used data from parent surveys distributed as part of the larger Fit Study.[5] We used mixed effects logistic regression to see if time elapsed between BMI being measured and the report being sent to parents was associated with either parent recall of receiving a report or concern about the report's results. Among 487 parents, there was no association between time elapsed and parents remembering the report (OR 0.1, 95% CI: -0.2, 0.4); among parents who remembered receiving a report, there was no association between time elapsed and being surprised at results (OR -0.1, 95% CI: -1.4, 1.2).

7. Differential effect of BMI reports by baseline weight status

While our primary aim was to determine the effect of BMI reports on pediatric obesity among students with a BMI ≥ 85th percentile at baseline, we also examined the effect of BMI reporting stratified by baseline weight category (eTable 1, below). Below, we summarize these findings and provide the equivalent change in weight to provide context for the results, since as baseline BMI z-scores increase, smaller changes in z-score represent larger absolute changes in weight.

Students with a BMI < 5th %tile at baseline: At baseline, 3% of students in both the BMI reporting and BMI screening groups fell into the lowest weight category. Among students in the BMI screening group (control), BMI z-scores increased by 0.27 from baseline to 1 year (which represents a 2.6 kg increase in weight), and by 0.32 from baseline to 2 years (equivalent to 6 kg). BMI z-scores among students in the BMI reporting group increased by an additional 0.08 z-scores (95% CI 0.01, 0.15) after 1-year (equivalent to 0.2 kg) and 0.18 z-scores (95% CI 0.08, 0.27) after 2 years (equivalent to 0.5 kg). There was no significant difference in the proportion of students who moved from the lowest weight category to a higher weight category after 1 (65% retained a BMI <5th %tile) or 2 years (54% retained a BMI <5th %tile).

The greater increase in weight among BMI reporting students compared to BMI screening students suggests that parents who received a BMI report stating that their child was underweight encouraged their child to increase their caloric intake. It is difficult to know if this represents a positive response or not, since it is not clear how students' diets might have changed (e.g., more low-nutrient/high-calorie foods or more total calories from a balanced diet). Similarly, if parents encouraged greater caloric intake, the form of that encouragement is not known, but it could represent a positive and supportive approach or an authoritative approach that created discord.

Students with a BMI ≥5th %tile and < 85th %tile at baseline: On average, BMI z-scores among students in the BMI screening group increased by 0.04 from baseline to 1 year, which represents a 5 kg increase in weight, and by 0.05 from baseline to 2 years (equivalent to almost 10 kgs). BMI z-scores among students in the BMI reporting group increased by 0.02 z-scores **less** (95% CI -0.04, -0.01) after 1-year (equivalent to 0.1 kg) and increased by an additional 0.03 z-scores (95% CI 0.00, 0.05) after 2 years (equivalent to 0.1 kg). There were no significant differences in the proportion of students who moved to the BMI <5th %tile category after 1 (2%) or 2 years (2%), nor in the proportion moving to a higher weight category after 1 (8%) or 2 years (11%). Less than 1% moved up by 2 categories, to the BMI >95th %tile, after 2 years.

The implications of the between-group differences at 1 and 2 years of follow-up are not clear. The differences are in opposite directions (a smaller increase at year 1 and a larger increase at year 2) and are small, making it difficult to draw a conclusion about any potential longer-term trends or impacts.

Students with a BMI ≥85th %tile. There was no effect of BMI reporting among students with a BMI between the 85th and 95th %tile, nor for students with a baseline BMI >95th %tile. There were significant between-group differences for students in the 2 lower weight categories (eTable 1).

Tables

eTable 1. Adjusted BMI z-Scores, by Students' Baseline Weight Category and Group

				1-yr change			2-year change		
	Baseline	1 Year	2 Year	Within-Group	Between-Group[A]	P Value[B]	Within-Group	Between-Group[A]	P Value[B]
All Students (N=16622)									
BMI <5th percentile (n=511)									
BMI Reporting	-2.19±0.04	-1.84±0.04	-1.69±0.04	0.35 [0.30, 0.40]	0.08 [0.01, 0.15]	0.021	0.50 [0.42, 0.57]	0.18 [0.08, 0.27]	0.000
BMI Screening	-2.13±0.04	-1.86±0.04	-1.81±0.04	0.27 [0.21, 0.32]			0.32 [0.23, 0.41]		
BMI 5th - 85th percentile (n=9577)									
BMI Reporting	-0.02±0.01	-0.001±0.01	0.06±0.02	0.02 [-0.01, 0.04]	-0.02 [-0.04, -0.01]	0.002	0.08 [0.03, 0.13]	0.03 [0.003, 0.05]	0.025
BMI Screening	0.003±0.01	0.05±0.01	0.06±0.02	0.04 [0.02, 0.07]			0.05 [0.01, 0.10]		
BMI 85th - 95th percentile (n=2938)									
BMI Reporting	1.34±0.02	1.29±0.02	1.27±0.03	-0.05 [-0.08, -0.02]	0.01 [-0.02, 0.04]	0.660	-0.07 [-0.12, -0.01]	0.004 [-0.04, 0.05]	0.848
BMI Screening	1.36±0.02	1.30±0.02	1.29±0.03	-0.06 [-0.09, -0.03]			-0.07 [-0.13, -0.02]		
BMI ≥95th percentile (n=3596)									
BMI Reporting	2.05±0.02	1.98±0.02	1.95±0.02	-0.07 [-0.10, -0.04]	-0.01 [-0.03, 0.02]	0.593	-0.10 [-0.15, -0.05]	0.01 [-0.03, 0.05]	0.653
BMI Screening	2.07±0.02	2.00±0.02	1.96±0.02	-0.06 [-0.09, -0.03]			-0.11 [-0.16, -0.06]		

Values are estimated marginal means±SE; 95% confidence intervals are shown in brackets []. Analyses adjusted for sex, race, district, grade, school-level percentage of students eligible for FRPM, and calendar year (except for model limited to students with 3 years of data).

[A] Between-group difference: BMI Reporting minus BMI Screening group.

[B] P-value for between-group difference.

eTable 2. Adjusted BMI z-Scores by Study Group, Among Students With a Baseline BMI ≥ 85th Percentile for Sex and Age in Grades 3-7 Based on Estimation Using Multiply Imputed datasets (n=7672)

				1-yr change			2-year change		
	Baseline	1 Year	2 Year	Within-Group	Between-Group[A]	P Value[B]	Within-Group	Between-Group[A]	P Value[B]
All students									
BMI Reporting	1.74±0.13	1.69±0.01	1.69±0.02	-0.05 -0.08, -0.02]	-0.004 [-0.02, 0.01]	0.51	-0.06 [-0.11, -0.00]	0.005 [-0.01, 0.02]	0.61
BMI Screening	1.76±0.01	1.71±0.01	1.70±0.02	-0.045 [-0.07, -0.02]			-0.06 [-0.11, -0.01]		
Hispanic students									
BMI Reporting	1.77±0.01	1.72±0.01	1.73±0.02	-0.04 [-0.07, -0.02]	0.001 [-0.01, 0.02]	0.93	-0.04 [-0.10, 0.01]	0.019 [-0.00, 0.04]	0.10
BMI Screening	1.79±0.01	1.74±0.01	1.72±0.02	-0.05 [-0.07, -0.02]			-0.06 [-0.11, -0.01]		
Non-Hispanic students									
BMI Reporting	1.68±0.02	1.61±0.02	1.59±0.02	-0.06 [-0.09, -0.03]	-0.015 [-0.04, 0.01]	0.22	-0.09 [-0.14, -0.03]	-0.023 [-0.06, 0.01]	0.20
BMI Screening	1.70±0.02	1.66±0.02	1.64±0.025	-0.05 [-0.08, -0.02]			-0.06 [-0.12, -0.01]		
Elementary students[C]									
BMI Reporting	1.76±0.01	1.70±0.01	1.69±0.02	-0.05 [-0.08, -0.03]	-0.009 [-0.02, 0.01]	0.28	-0.07 [-0.12, -0.02]	0.001 [-0.02, 0.02]	0.93
BMI Screening	1.77±0.01	1.73±0.01	1.70±0.02	-0.05 [-0.07, -0.02]			-0.07 [-0.12, -0.02]		
Non-Elementary students									
BMI Reporting	1.74±0.02	1.66±0.02	1.62±0.03	-0.07 [-0.10, -0.05]	0.004 [-0.02, 0.03]	0.70	-0.11 [-0.16, -0.06]	0.010 [-0.02, 0.05]	0.57
BMI Screening	1.76±0.02	1.68±0.02	1.63±0.02	-0.08 [-0.10, -0.05]			-0.12 [-0.17, -0.07]		

Values are estimated marginal means±SE; 95% confidence intervals are shown in brackets []. Analyses adjusted for sex, race (except in models stratified by Hispanic students), district, grade (except for models stratified by grade-level), school-level percentage of students eligible for FRPM, and calendar year.

[A] Between-group difference: intervention less control group

[B] p-value for groupXtime interaction

[C] Elementary: In grade 3-5 at baseline

eTable 3. Adjusted Weight Stigmatization Outcomes in Grades 4-8, Stratified by Baseline Perceived Weight Status (n=14318). BMI Reporting group vs. BMI Screening and Control groups combined.

				1-yr change			2-year change		
	Baseline	1 Year	2 Year	Within-Group	Between-Group	P Value[A]	Within-Group	Between-Group	P Value[A]
Family weight talk index (range 1 to 5)									
Underweight									
BMI Reporting	1.59±0.03	1.63±0.03	1.58±0.04	0.03 [-0.03, 0.10]	0.07 [0.01, 0.14][B]	0.035	-0.01 [-0.11, 0.08]	0.05 [-0.05, 0.15][B]	0.33
BMI Screening	1.61±0.02	1.57±0.02	1.55±0.03	-0.04 [-0.09, 0.01]			-0.07 [-0.14, 0.01]		
About the right weight									
BMI Reporting	1.40±0.02	1.40±0.02	1.41±0.03	-0.00 [-0.05, 0.04]	-0.01 [-0.06, 0.03] [B]	0.042	0.01 [-0.06, 0.09]	-0.02 [-0.09, 0.04] [B]	0.50
BMI Screening	1.39±0.02	1.40±0.01	1.42±0.03	0.01 [-0.02, 0.05]			0.04 [-0.03, 0.10]		
Somewhat overweight									
BMI Reporting	1.70±0.03	1.65±0.03	1.68±0.05	-0.06 [-0.12, 0.01]	-0.04 [-0.11, 0.03] [B]	0.27	-0.03 [-0.13, 0.08]	0.06 [-0.05, 0.17] [B]	0.25
BMI Screening	1.72±0.02	1.79±0.02	1.63±0.04	-0.02 [-0.07, 0.03]			-0.09 [-0.17, -0.01]		
Very overweight									
BMI Reporting	2.19±0.04	1.98±0.03	1.98±0.07	-0.21 [-0.29,-0.13]			-0.22 [-0.36, -0.07]		
BMI Screening	2.10±0.05	2.03±0.05	1.66±0.10	0.08 [-0.20, 0.04]	0.13 [0.01, 0.27] [B]	0.075	-0.45 [-0.66, -0.25]	-0.24 [-0.47,-0.00] [B]	0.046
Family encourages dieting (range 1 to 4)									
Underweight									
BMI Reporting	2.23±0.05	2.20±0.04	2.03±0.07	-0.03 [-0.14,0.07]	0.03 [-0.07,0.14][B]	0.54	-0.21 [-0.37,-0.04]	0.01 [-0.15,0.17][B]	0.91
BMI Screening	2.29±0.03	2.23±0.03	2.08±0.06	-0.07 [-0.14,0.01]			-0.22 [-0.34,-0.09]		
About the right weight									
BMI Reporting	2.24±0.04	2.18±0.03	2.16±0.05	-0.07 [-0.14,0.01]	-0.05 [-0.12,0.02] [B]	0.14	-0.09 [-0.21,0.04]	0.07 [-0.03,0.18] [B]	0.17
BMI Screening	2.26±0.03	2.25±0.02	2.10±0.04	-0.02 [-0.08,0.04]			-0.16 [-0.27,-0.06]		
Somewhat overweight									
BMI Reporting	2.75±0.05	2.70±0.05	2.53±0.08	-0.06 [-0.16,0.05]	0.03 [-0.08,0.14] [B]	0.64	-0.22 [-0.39,-0.05]	-0.11 [-0.28,0.07] [B]	0.23
BMI Screening	2.75±0.03	2.67±0.03	2.64±0.06	-0.08 [-0.16,-0.01]			-0.11 [-0.25,0.02]		
Very overweight									
BMI Reporting	2.87±0.09	2.94±0.09	3.11±0.16	0.07 [-0.13,0.26]	0.14 [-0.08,0.37] [B]	0.21	0.24 [-0.09,0.57]	0.44 [0.06,0.82] [B]	0.024
BMI Screening	2.85±0.06	2.77±0.06	2.66±0.11	-0.08 [-0.21,0.05]			-0.20 [-0.42,0.03]		

Values are estimated marginal means±SE; 95% confidence intervals are shown in brackets []. Analyses adjusted for sex, race, district, grade, school-level percentage of students eligible for FRPM, and calendar year. P-values for Wald test indicating interaction by weight status: Family weight talk: P=0.007; Family weight stigma: P=0.01; Family encourages dieting: P=0.0495.

[A] P-value for between-group difference.

[B] Between-group difference: BMI Reporting group minus BMI Screening and Control groups combined.

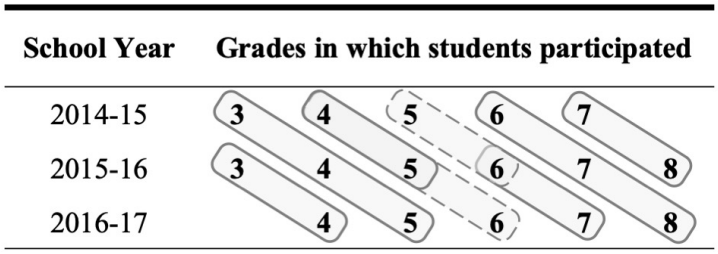
Figures

eFigure 1. Study Groups Constituting the Exposed/Intervention and Control Groups for Each Study Outcome

Outcome	Exposed/ Intervention Group	Control Group
Weight Status [A]	BMI Reporting (Arm 1)	BMI Screening (Arm 2)
Child- & Peer-related Adverse Outcomes [B]	BMI Reporting & BMI Screening (Arms 1 & 2)	Control (Arm 3)
Family-related Adverse Outcomes [B]	BMI Reporting (Arm 1)	BMI Screening & Control (Arms 2 & 3)

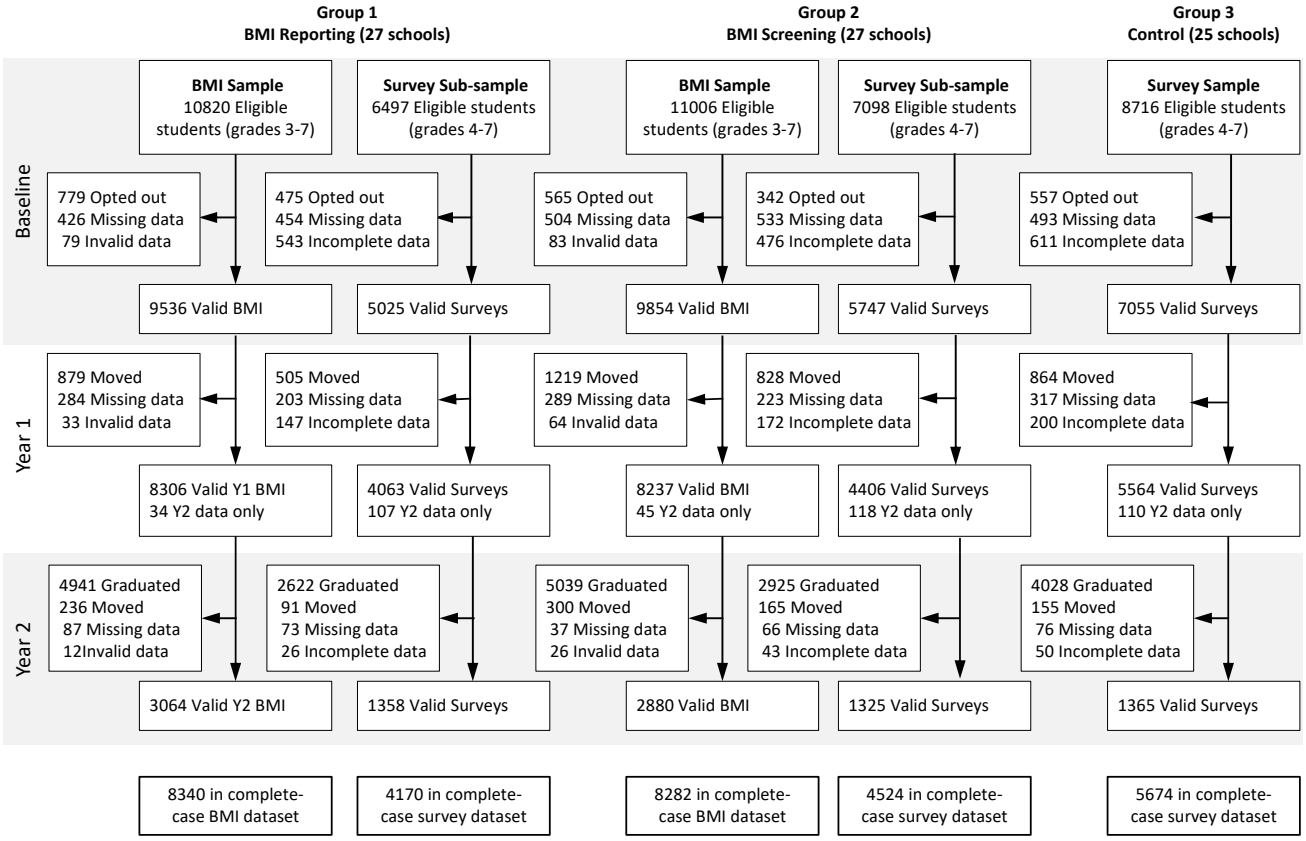
[A] Restricted to students with baseline BMI ≥ 85th percentile
[B] Restricted to students in grades 4-7 at baseline

eFigure 2. Longitudinal Data Collection



Diagonal boxes indicate students being followed over time. Solid boxes - students in K-5 and 6-8 schools; dashed boxes - students in K-6 and K-8 schools. BMI was assessed in all grades; surveys were administered to students in grades 4-8.

eFigure 3. Participant Flow Among Eligible Students (N=30542) in Grades 3-7 in 79 California Schools



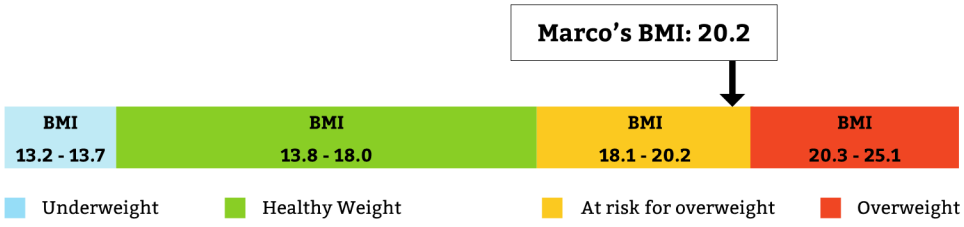
"Moved" indicates students lost to follow-up because they moved from their school. "Graduated" indicates students who completed the study (graduated from school or entered study in second cohort, with only 1 year of follow-up possible).
For groups 1 and 2, the "BMI Sample" includes all students in the "Survey Sub-sample," which was limited to youth in grades 4-7.

eFigure 4. BMI Report

A. Front of BMI Report

Your son, Marco Smith, was measured at school in March 2015. He was 3 feet 12 inches tall and weighed 65 pounds. **Marco's body mass index (BMI) was 20.2.**

BMI is a ratio of a child's weight to height. Doctors use BMI to see if a child's weight might be putting him or her at risk for health problems. The colored bar below shows BMI ranges for **8-year-old boys.** The arrow points to Marco's BMI, which places him in the **at risk for overweight range.**



Why does this matter?

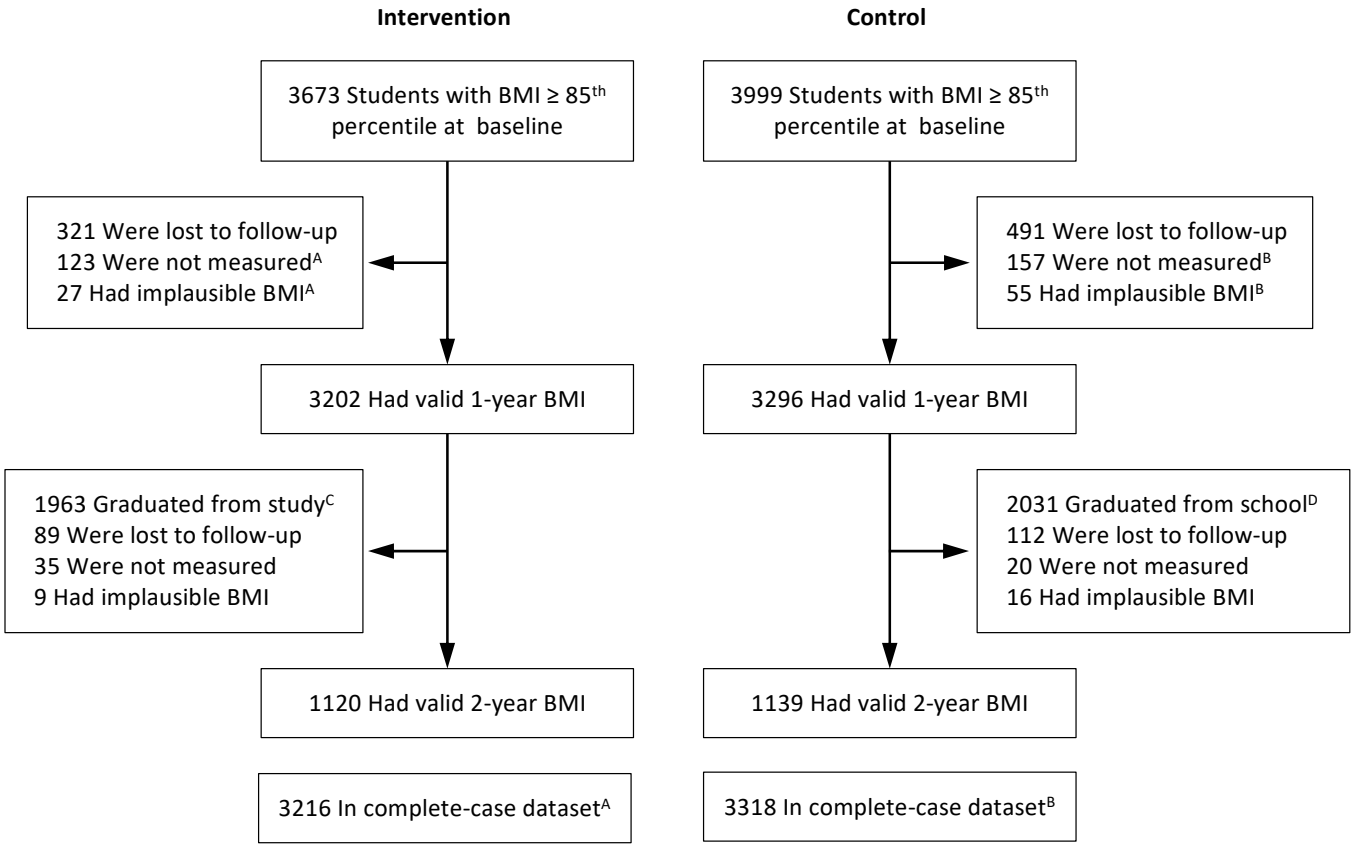
Studies have shown that many overweight children already have high blood pressure, high cholesterol, or early signs of diabetes. Also, overweight children are more likely to become obese as adults, which can lead to serious health problems. If you have any questions or concerns about Marco's BMI, please share this letter with his doctor or our school health staff.

What can you do?

The good news is that even small changes can make a big difference in your child's health. **Turn the page** to see what you can do to keep your family healthy. You can also visit **www.choosemyplate.gov** for more tips and resources. All children, no matter what their weight, should be physically active and eat a healthy diet.

B. Infographic on Reverse of BMI Report

eFigure 5. Participant Flow Among Students With a Baseline BMI ≥ 85th Percentile for Age and Sex



[A] 14 students not measured or with implausible values in Year 1 had a valid BMI in Year 2.
[B] 22 students not measured or with implausible values in Year 1 had a valid BMI in Year 2.
[C] 894 students in first cohort (Fall 2014) graduated from the study school; 1069 students were in the second cohort, for whom study ended after 1 year of follow-up.
[D] 903 students in first cohort graduated from the study school; 1128 students were in the second cohort, for whom study ended after 1 year of follow-up.

eReferences

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