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RESEARCH ARTICLE

Association of Clinician Behaviors and Weight Change in School-Aged Children

Christy B. Turer, MD, MHS,[1,2,3,4,5] Sarah E. Barlow, MD, MPH,[1,3,5,6] David B. Sarwer, PhD,[7] Brian Adamson, MS,[3,4] Joanne Sanders, MS,[3,4] Chul Ahn, PhD,[3,4] Song Zhang, PhD,[3,4] Glenn Flores, MD,[8,9] Celette Sugg Skinner, PhD[3,4]

Introduction: This study uses clinical practice data to determine whether recommended weight management clinician behaviors are associated with weight status improvement in children aged 6–12 years who are overweight or obese.

Methods: Electronic health record data (2009–2014) from 52 clinics were used. Weight status was examined from 1 visit to the next as dichotomous improvement (versus worsening or no change) and change in percentage overweight (over sex/age-specific BMI_{95}). The primary predictor was a clinician behavior variable denoting attention to high BMI alone or with assessment of medical risk/comorbidities and was defined using combinations of diagnostic codes and electronic health record orders. Covariates included time between visits and medications associated with weight gain or loss. Adjusted multilevel regression models examined the association of the clinician behavior variable with weight status improvement. Analyses were conducted from 2015 to 2018.

Results: Children (n=7,205) had a mean age of 8.9 years; 45.5% were overweight, 54.5% obese, and 81.1% publicly insured. For 62% of overweight children, and 38%, 21%, and 11% of those in obesity classes 1–3, respectively, no attention to high BMI/medical risk assessment at any visit was identified. Children with evidence of clinician attention to high BMI alone and who underwent a medical risk assessment had significantly greater AOR of improvement in percentage of BMI_{95} and percentage of BMI_{95} change: BMI alone, AOR=1.2 ($p<0.001$) and $\beta = -0.3$ ($p>0.05$); BMI/medical risk, AOR=1.2 and $\beta = -0.5$ (both $p<0.001$). Other factors associated with weight status improvement included prescription medications (1 or more prescriptions associated with either weight loss or none associated with weight gain) and fewer months between visits.

Conclusions: This is the first study to use electronic health record data to demonstrate that widely recommended clinician behaviors are associated with weight status improvement in children aged 6–12 years who are overweight or obese.

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From the [1]Department of Pediatrics, University of Texas Southwestern Medical Center, Dallas, Texas; [2]Department of Medicine, University of Texas Southwestern Medical Center, Dallas, Texas; [3]Department of Population & Data Sciences, University of Texas Southwestern Medical Center, Dallas, Texas; [4]Harold C. Simmons Comprehensive Cancer Center, University of Texas Southwestern Medical Center, Dallas, Texas; [5]Department of Pediatrics, Children's Medical Center, Dallas, Texas; [6]Department of Pediatrics, Texas Children's Hospital, Houston, Texas; [7]College of Public Health, Center for Obesity Research and Education, Temple University, Philadelphia, Pennsylvania; [8]Division of Research, Connecticut Children's Medical Center, Hartford, Connecticut; and [9]Department of Pediatrics, University of Connecticut School of Medicine, Farmington, Connecticut

Address correspondence to: Christy Boling Turer, MD, MHS, Department of Pediatrics, University of Texas Southwestern Medical Center, 5323 Harry Hines Boulevard, Dallas TX 75390.
E-mail: Christy.Turer@UTSouthwestern.edu.

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INTRODUCTION

Primary care providers need evidence-based guidance on how to lower the relative weight and disease risk of children who are overweight and obese.[1,2] Clinicians are encouraged to use clinic-based opportunities to identify children with high BMIs, assess for medical or behavioral risks, and treat overweight or obesity and related comorbidities.[1,3–9] The goal of these seemingly low-intensity clinician behaviors is to activate the intrinsic motivation of parents and children for adopting healthier lifestyles by communicating how a child's unhealthy BMI is impacting health—for example, through comorbidity assessment—and then provide weight management support through diet and lifestyle modification plans, follow-up visits, and referrals to nutrition and weight management programs.[10] Despite recommendations of professional organizations (the Expert Committee on Assessment/Treatment of Childhood Overweight/Obesity; U.S. Preventive Services Task Force; and Bright Futures Guidelines) to screen for high BMI, assess either medical or behavioral risks or both, and treat high BMI and comorbidities, not enough providers deliver these services.[1,3,5,8,9,11–16] Understanding whether their delivery is associated with weight status improvement may motivate more providers to use them.

The authors previously outlined key features of recommended weight management healthcare services whose delivery could be identified using indirect electronic health record (EHR) evidence, then developed a rule-based algorithm to detect the most valid EHR evidence that could serve as a proxy for provider "attention to" high BMI alone or in combination with "attention to" medical risk/comorbidities.[17] The term "attention" was chosen rather than "performance" of BMI/comorbidity screening to convey that the provider delivery of these guideline-based healthcare services was determined using indirect EHR evidence. Detailed methods have been published, including steps used to convert guideline-recommended clinician behaviors into electronic phenotypes and validation of the phenotype's ability to detect evidence of the clinician behaviors.[17]

The objective of this study is to examine, at primary care visits, proportions of children aged 6–12 years who are overweight and obese and who have EHR-documented attention to high BMI alone or in combination with obesity-related comorbidities, and whether these weight management services are associated with weight status improvement. The study hypothesis is that documented evidence of these services is associated with weight status improvement.

METHODS

Study Population

The cohort for this retrospective study was built using primary care data extracted from an EHR shared by 52 clinics in greater Dallas, Texas. Researchers collected primary care visits; weight and height measurements; diagnosis codes; and orders for medicines, laboratories, and referrals to nutrition, weight management, and community-based programs.

The study was approved with a waiver of informed consent by the IRB of University of Texas Southwestern.

Academic, community, and private clinics contributed data. The academic/teaching, resident-staffed continuity clinic has been caring for predominantly publicly insured, underserved children for 30 years. The community-based and private clinics serve a mix of publicly and privately insured children. These clinics use special efforts to address BMI screening, including EHR-enabled growth charts and visit flow sheets with BMI percentiles, which are red –bold highlighted when high. Community-based clinics also deliver education on BMI screening and patient-centered communication (starting when clinics opened in 2010).

The study cohort was assembled by identifying children aged 6–12 years with overweight or obesity and primary care visit data from 2009 to 2014 (Figure 1). This age group was studied because prior evidence suggested that weight management interventions may be most effective for school-aged children with overweight or obesity.[18,19] Study inclusion required: 1 or more well-child or nonwell-child or noninfectious illness visits (later defined), valid weight and height data at 2 or more visits, a BMI percentile of ≥85 at 2 or more visits, and 1 or more well-child visits between ages 6 and 12 years. Exclusion criteria included conditions in which typical weight management advice does not apply (e.g., Type 1 diabetes, inherited or congenital disorders, and organ failure or transplant).

Outcomes from 1 visit at which a child had overweight or obesity to the next (at which child could be healthy weight) were examined, rather than from 1 well-child visit to the next, because many providers addressed BMI at nonwell-child visits, and many children with chronic conditions (including overweight and obesity) may not receive regular well-child visits.[20] Primary study analyses excluded nonwell-child visits with infectious illness diagnosis codes, because weight status might improve because of an acute illness (e.g., gastroenteritis), given that infectious disease–related cytokines can temporarily raise metabolic rates.[21] Primary data presented in this study, therefore, include 3 visit types: well-child visits with and without infectious illness diagnoses, and nonwell-child visits without infectious illness diagnoses. The differences in results from including nonwell-child visits with infectious illness diagnoses are described.

Measures

The primary independent variable was a 3-level practice behavior variable that included: attention to overweight/obesity/BMI alone ("BMI Alone"), attention to BMI with evidence of attention to comorbidities ("BMI/Medical Risk"), and "No Attention" to either high BMI or BMI/Medical Risk.

Attention to BMI, as described previously,[17] entailed identifying evidence from diagnosis codes, laboratory tests, procedures, referrals, and prescriptions that providers assessed BMI percentiles/identified

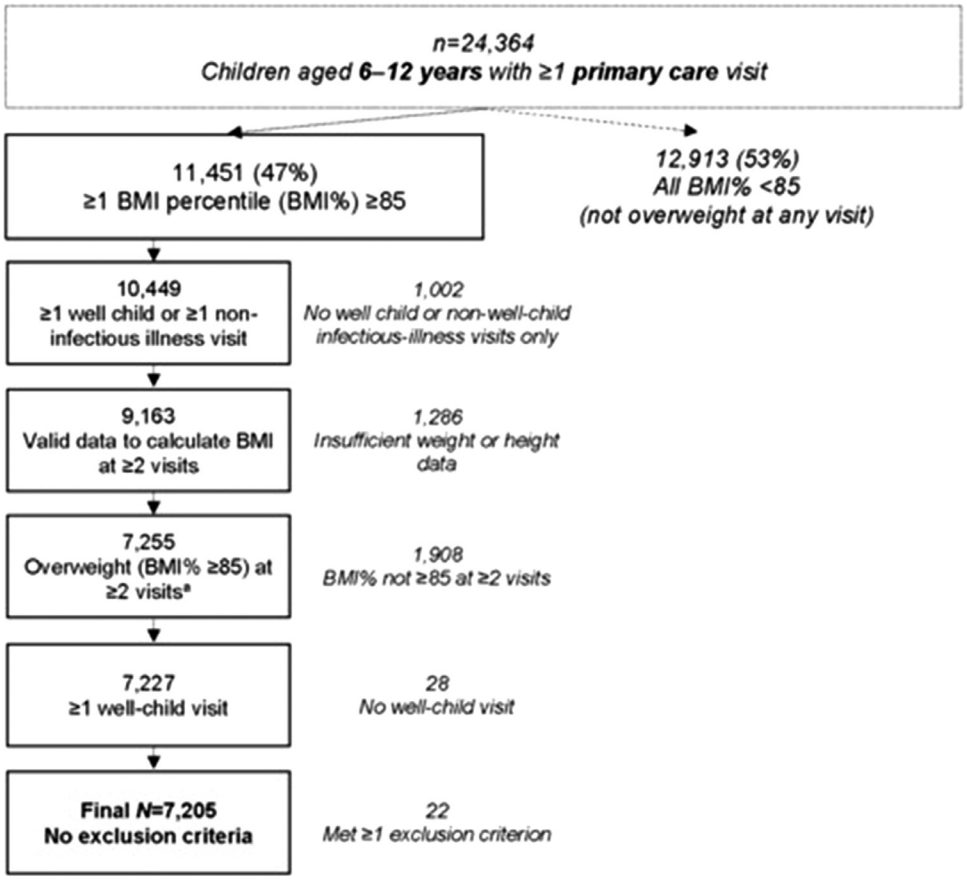

Figure 1. Sample flow.

Note: EHR data were extracted in 2014. The study sample was drawn from a population with 47% of children aged 6–12 years who had EHR evidence of overweight or obesity at 1 or more primary care visits. Final sample included 7,205 children aged 6–12 years with overweight or obesity and 1 or more well-child visits. The study team only received data for children with overweight and obesity (n=11,451). EHR was adopted by academic/teaching clinics in November, 2009 and community-based and private clinics at different time points from 2010 to 2012.

[a]Inclusion required 2 elevated BMI percentiles to increase the likelihood that children in the cohort truly had overweight or obesity (e.g., did not have a single BMI elevation owing to error). Because the study team received all visit data for children, including visits when the child was aged <6 years, 1 of the 2 BMI elevations needed for inclusion could come from a visit before age 6 years.

EHR, electronic health record.

children with overweight or obesity, performed laboratory studies for genetic forms of obesity, recommended lifestyle changes, or facilitated referral to nutrition and weight management programs (Appendix Text, available online).

For those with overweight or obesity, screening for comorbidities is recommended.[1,5,22] Attention to comorbidities entailed identifying evidence that providers addressed hypertension, dyslipidemia, dysglycemia, or fatty liver—for example, through use of billing codes, performing laboratory studies, or prescribing pharmacotherapy for these conditions (Appendix Tables 1–5, available online).[22]

Attention to comorbidities alone without attention to BMI at the same visit (identified in 3% of visits) was treated as No Attention. This categorization minimized misclassification bias during development and validation of the weight management clinician behavior electronic phenotypes, including finding in video-recorded communication data that pediatricians almost never communicated regarding obesity comorbidities without discussing BMI (observed in 1% of n=93 valid [of 100 total] visit recordings).[17]

Chart and text review showed that the algorithm to detect weight management clinician behaviors had good specificity (89.4%) for detecting No Attention (to high BMI) and sensitivity for identifying attention to BMI alone (96.0%) and BMI/comorbidities (96.1%).[17] The algorithm's specificity for detecting No Attention was consistent with the research team's data from recorded visits in which 12% of visits with directly recorded BMI communication had no corresponding EHR documentation.[23]

The primary outcome was weight status improvement, defined dichotomously as any versus no or zero improvement in percentage of BMI_{95} (%-of-BMI_{95}). This outcome answered the clinically important question of whether BMI improves at a follow-up visit after a visit with evidence that a clinician addressed high BMI alone or with comorbidities. A secondary outcome, %-of-BMI_{95} change, was added to describe how much %-of-BMI_{95} change is associated with attention to high BMI alone or with comorbidities. Although the %-of-BMI_{95} change needed to improve comorbidities in children is unclear, modest weight loss (<5%–10%) improves most cardiovascular risk factors in adults.[24]

In contrast to BMI %/SD score, changes in %-of-BMI_{95} reflect comparable weight changes (in pounds) across sex/age and magnitude of overweight (Appendix Table 6, available online).[25] Percentage of BMI_{95} was calculated as:

$$(\text{BMI}/\text{BMI at 95th age/sex percentile}) * 100.$$

Sensitivity analyses using BMI %/SD score produced comparable results. Weight and height were measured directly by clinic staff using standardized protocols. Outlier measurements were identified using recommended methods.[26,27] Only 1.2% of the sample had outlying values; therefore, no outlier adjustments were made.

For analyses of %-of-BMI_{95}, improvement from 1 visit to the next, covariates were determined at 3 time points: (1) baseline, child's first visit in cohort; (2) "index" visit (time-varying) to examine evidence of attention to BMI/medical risk from 1 visit to the next; and (3) the next "follow-up" visit (time-varying) to assess %-of-BMI_{95} improvement or change at the visit immediately following the "index" visit.

Baseline covariates included sex, race/ethnicity, clinic site, and age (at the first visit when a child met the study inclusion or exclusion criteria).

"Index" visit covariates included the primary independent practice behavior variable, %-of-BMI_{95} at visit (continuous), visit type (well-child/well-child with infectious illness/nonwell-child noninfectious illness visit), age at visit, presence of mental health conditions, and disease complexity. Disease complexity was categorized as no chronic diseases, simple chronic disease (e.g., allergies), or complex chronic disease (e.g., severe or persistent asthma) determined using a published algorithm.[28]

"Follow-up" visit covariates included time interval between visits, lacked prescription of at least 1 medication associated with weight gain within the preceding 30 days, and prescription of 1 or more medicines associated with weight loss within 30 days.

Medications associated with weight gain or weight loss were included in the analysis as potential confounders. No child in the cohort was prescribed any weight loss medication approved by the U.S. Food and Drug Administration. To identify other medicines with evidence of association with weight gain or loss, 3 independent reviewers referenced 2 drug side effect databases (Micromedex and Lexicomp[29]). Twenty-five percent (n=115) of medications were reviewed by 2 reviewers. Discrepancies (7.8% of drugs reviewed in duplicate) were resolved through rereferencing drug databases and consensus. It was beyond the study's scope to probe the strength of each medicine's effect on weight. Therefore, all medicines with evidence of impact on weight were included in the analyses.

Four additional variables were described (though not included in analyses): (1) baseline weight status (defined in Table 1),[22,26,30] (2) time in cohort, (3) cohort retention, and (4) time interval between visits (each defined in Appendix Table 7, available online).

Statistical Analysis

Descriptive statistics were used to summarize baseline sample characteristics and the highest category of weight management practice behaviors received (from first to last visit in the cohort), where lowest was no evidence of BMI attention at any visit, and highest was attention to both BMI/medical risk at 1 or more visits. Because weight status improvement was assessed from 1 visit to the next, children could have at least 1 visit interval with weight status improvement and others with no change or worsening. Thus, to account for a patients' repeated measurements and the hierarchical correlation structure among observations, analyses included clinic and patient (clustered in clinic) random effects.

Two multilevel, mixed-effects regression models were used to examine associations of the practice behavior predictor with %-of-BMI_{95} improvement (yes or no) and change. Models were adjusted for %-of-BMI_{95} and time in cohort at the "index" visit (time in cohort equaled zero when baseline and "index" visits were the same visit), visit type (well-child visit or not, and whether well-child had an infectious illness diagnosis code), and other covariates (included after testing and finding no collinearity among them). Results are presented as AORs and β-intercepts with 95% CIs. Statistical significance was determined using a 2-tailed $p<0.05$. Analyses were conducted 2015–2018 using SAS, version 9.4.

RESULTS

Data for the cohort came from 11,451 children aged 6–12 years with overweight or obesity, drawn from 24,364 children aged 6–12 years with at least 1 primary care visit at 1 of the 52 clinics (47% prevalence overweight or obesity) (Figure 1). The final data set contained 7,205 patients followed at 50 clinics (2 clinics had fewer than 10 children, preventing model convergence). Collectively, children had 23,974 visit-to-visit intervals. Average time in the cohort was 1.5 years. Average retention was 72%. Median time interval between visits was 92.0 days.

The mean child age was 8.9 (SD=2.1) years (Table 1). More than half had obesity at baseline. Most were black or Latino and were publicly insured; 42% were followed at the academic/teaching clinic, 39% at community-based clinics, and approximately 19% at private practices. Sixty percent had no evidence of chronic disease.

Whereas 51.3% had been prescribed a medication associated with weight gain, only 8.3% had been prescribed a medication associated with weight loss. Medications identified in drug databases as associated with weight gain included medications for attention-deficit hyperactivity disorder (including clonidine), asthma/allergy/autoimmune disorders (e.g., steroids), diabetes (e.g., sulfonylureas), epilepsy (e.g., valproate), mental health (e.g., antipsychotics), and gastrointestinal conditions (e.g., cyproheptadine). Medications identified as associated with weight loss included medications for attention-deficit hyperactivity disorder (e.g., stimulants), inflammatory disorders (e.g., mesalamine), diabetes (e.g., metformin), migraines (e.g., topiramate), mental health (e.g., bupropion), and thyroid disease (e.g., liothyronine) (Appendix Table 8, available online).

In the overall cohort, proportions of children with EHR evidence of clinician attention to both high BMI/comorbidities, high BMI alone, or neither at any visit were 33.1%, 21.4%, and 45.5%, respectively. Proportions lacking evidence of attention to high BMI at all (No Attention) decreased with increasing BMI categories,

Table 1. Sample Characteristics Among Children Aged 6–12 Years With Overweight or Obesity in the Primary Care Cohort

Characteristic	*n*	Percentage or mean (SD)
Age, years[a]	7,205	8.9 (± 2.1)
BMI percentile category[a]		
Overweight	3,277	45.5
Obesity Class 1	2,670	37.1
Obesity Class 2	931	12.9
Obesity Class 3	327	4.5
Sex		
Female	3,423	47.5
Male	3,782	52.5
Race/ethnicity		
Black, non-Latino	1,454	20.2
Latino	3,895	54.0
White, non-Latino	992	13.8
Other	864	12.0
Health insurance		
Public	5,842	81.1
Private	1,226	17.0
Other or unknown	137	1.9
Clinic setting		
Academic/teaching continuity clinic	3,030	42.1
Community-based clinics	2,812	39.0
Private practice clinics	1,363	18.9
Disease complexity		
No chronic diseases	4,327	60.0
No complex chronic diseases	2,043	28.4
Complex chronic disease(s)	835	11.6
Mental or behavioral health condition[a]		
No	6,643	92.2
Yes	562	7.8
Ever prescribed medicine associated with weight gain[b]		
No	3,507	48.7
Yes	3,698	51.3
Ever prescribed medicine associated with weight loss[b]		
No	6,607	91.7
Yes	598	8.3

[a]At first visit, defined as first primary care visit on or after the child's sixth birthday with BMI% ≥85. BMI percentile categories were defined as following:
1. overweight, BMI % 85–<95;
2. obesity Class 1, BMI % 95–<120% of BMI_{95} (or BMI ≥30 kg/m^2, whichever was lower);
3. obesity Class 2, 120–<140% of BMI_{95} (or BMI ≥35 kg/m^2, whichever was lower);
4. obesity Class 3, ≥140% of BMI_{95} (or BMI ≥40 kg/m^2, whichever was lower).

[b]During time in cohort, defined as the time from the first primary care visit on or after the child's sixth birthday with BMI% ≥85% to the most recent visit at the time of data extraction.

from 62% among those with overweight to 11% among those with obesity Class 3 (Figure 2). Conversely, attention to high BMI in combination with medical risk at any visit proportionately increased with higher BMI categories, from 18% among those with overweight to 74% among those with obesity Class 3.

In bivariate and multivariable analyses, attention to high BMI alone and in combination with comorbidities were associated with a likelihood of %-of-BMI_{95} improvement (Table 2). These clinician behaviors also were associated with %-of-BMI_{95} change in bivariate analysis BMI alone (β= −0.71, 95% CI= −0.99, −0.44) and BMI/medical risk (β= −1.22, 95% CI= −1.51, −0.94; Appendix Table 9, available online). After adjustment, only combined attention to BMI/medical risk was associated with %-of-BMI_{95} change (β= −0.49, 95% CI= −0.80, −0.18).

Other factors associated with %-of-BMI_{95} improvement in both bivariate and multivariable analyses

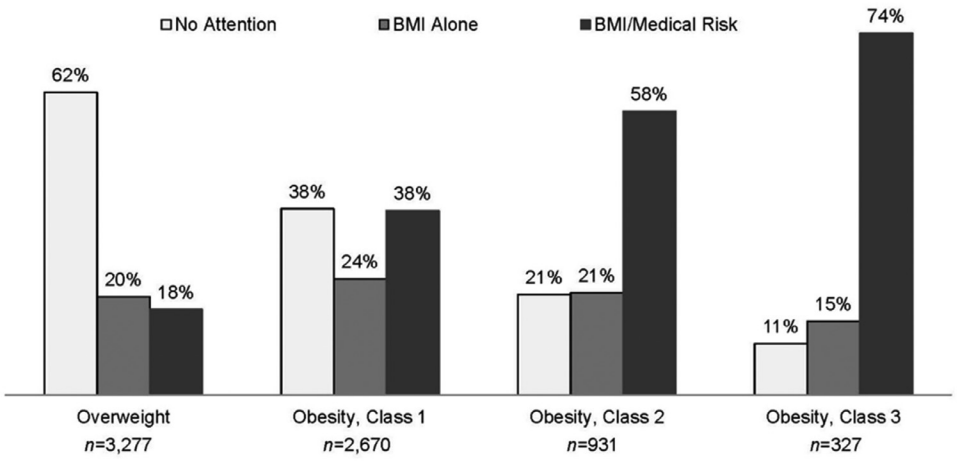

Figure 2. Percentage of children aged 6–12 years with overweight and obesity (n=7,205) with evidence of attention to overweight/obesity/high BMI alone, attention to both BMI and medical risk/presence of obesity comorbidities, and no attention at visits[a] in study cohort, by BMI category.[b]

Notes: Rates of clinician behaviors improve directly with BMI category. For example, the percentage of children with overweight or obesity lacking evidence of attention to both high BMI and medical risk is 62% among children with overweight and improves to 11% of children with obesity Class 3.

[a]The highest weight management practice behavior ever performed at a visit during time in cohort. "No Attention" indicates no evidence of attention to high BMI alone or with medical risk at any visit. Children coded as "BMI Alone" lacked evidence of attention to both BMI and medical risk at the same visit or at any visit. Children coded as "BMI/Medical Risk" had evidence of attention to both BMI and medical risk at 1 or more visits; these children may also have had 1 or more visits with evidence of attention to high BMI alone. Children coded as having attention to medical risk without attention to high BMI were included in "No Attention" category.

[b]BMI category is the baseline BMI category at each child's first visit documented in the electronic health record at which child met study inclusion criteria.

included: shorter time interval between visits, prescription of medications associated with weight loss, when the "index" visit was a well-child visit, older age at cohort entry, higher %-of-BMI_{95} at the "follow-up" visit, and clinic setting (community and private with greater odds). Two additional factors were associated with %-of-BMI_{95} improvement in the multivariable (but not bivariate) analysis: lack of prescription of medications associated with weight gain was associated with greater likelihood of %-of-BMI_{95} improvement and black race with a lower likelihood. Factors not associated with %-of-BMI_{95} improvement were sex, presence of chronic conditions, and mental or behavioral conditions.

In sensitivity analyses that included infectious illness visits, additional factors associated with %-of-BMI_{95} improvement in multivariable analysis included: attention to high BMI alone (AOR=1.2, 95% CI=1.1, 1.3) and lack of prescription of medications associated with weight gain (AOR=1.2, 95% CI=1.04, 1.3).

DISCUSSION

The principal finding from this study of routine clinical practice data is that pediatric provider attention to high BMI alone or with attention to comorbidities is associated with approximately 20% greater likelihood of weight status improvement in children aged 6–12 years with overweight and obesity. Attention to high BMI in combination with medical risk/comorbidities is associated with an approximately 0.5% reduction in %-of-BMI_{95}. Although findings suggest that identifying overweight or obesity and assessing comorbidities would have a small impact for individual children, the population-level impact of increasing the delivery of these weight management healthcare services in primary care would be quite large. Overweight or obesity affects approximately 30% of 7.4 million U.S. children aged 6–11 years, and 94% of these children visit a pediatrician yearly.[30,31] Therefore, minor improvements in clinical education and practice support that extend attention to high BMI to those lacking this attention could result in %-of-BMI_{95} improving among 200,000 children yearly.

These findings add novel evidence from routine clinical practice data that guideline-recommended weight management healthcare services are associated with weight status improvement. Previous work has shown suboptimal rates of provider communication regarding high BMI.[3,8,9,11–16] Yet, parental recognition that their child is overweight and that the high weight is a health problem is associated with parental readiness to make lifestyle changes to improve their child's weight.[32] In previous studies conducted by the author's team, parents of children with overweight and obesity reported in focus groups and surveys that checking for weight-related health problems was the single most important thing a pediatrician could do to help their

Table 2. Bivariate and Multivariable Analysis of Factors Associated With Dichotomous Improvement in Percentage of BMI_{95} in Children With Overweight or Obesity From One Visit to the Next (*n*=7,205)

	Improvement (Y/N) in %-of-BMI_{95}	
Predictor or covariate	**Crude OR[a] (95% CI)**	**AOR[a] (95% CI)**
Clinician behavior predictor[b]		
No attention to high BMI/medical risk/comorbidities	ref	ref
Attention to high BMI alone	**1.30 (1.21, 1.40)**	**1.18 (1.09, 1.28)**
Attention to high BMI and medical risk/comorbidities	**1.43 (1.32, 1.55)**	**1.23 (1.13, 1.35)**
Time interval between visits		
≥1 year	ref	ref
6 months–<1 year	**1.17 (1.06, 1.30)**	**1.27 (1.14, 1.41)**
4–<6 months	**1.18 (1.06, 1.32)**	**1.36 (1.21, 1.52)**
2–<4 months	**1.30 (1.17, 1.43)**	**1.50 (1.35, 1.67)**
<2 months	**1.46 (1.33, 1.61)**	**1.77 (1.60, 1.96)**
Prescribed medicine associated with weight loss[c]	**1.29 (1.07, 1.56)**	**1.31 (1.08, 1.58)**
Index visit was well-child visit[b] (versus nonwell-child)	**1.25 (1.18, 1.32)**	**1.30 (1.22, 1.39)**
Age in years at cohort entry, adjusted for index visit age	**1.03 (1.01, 1.04)**	**1.05 (1.02, 1.09)**
%-of-BMI_{95} at index visit[b,d]	**1.01 (1.01, 1.01)**[d]	1.01 (1.00, 1.01)[d]
Clinic setting		
Academic/teaching	ref	ref
Community	**1.09 (1.03, 1.15)**	**1.08 (1.02, 1.14)**
Private	**1.09 (1.01, 1.18)**	**1.12 (1.02, 1.22)**
Not prescribed medicine associated with weight gain[c]	1.07 (0.97, 1.17)	**1.12 (1.02, 1.24)**
Race/ethnicity		
White, non-Latino	ref	ref
Black, non-Latino	0.94 (0.85, 1.04)	0.91 (0.83, 1.00)[d]
Latino	0.99 (0.91, 1.07)	0.95 (0.87, 1.03)
Other	1.06 (0.94, 1.19)	1.04 (0.92, 1.16)
No mental or behavioral condition[b]	0.94 (0.84, 1.04)	1.04 (0.93, 1.16)
Male sex (vs. female)	1.02 (0.97, 1.07)	1.01 (0.96, 1.06)
Chronic conditions[b]		
No chronic conditions	ref	ref
Simple chronic conditions	0.98 (0.93, 1.04)	0.98 (0.92, 1.04)
Complex chronic conditions	1.07 (0.99, 1.14)	0.98 (0.91, 1.06)

Note: Boldface indicates statistical significance ($p<0.05$)
Likelihood ratio >1.0 indicates covariate associated with any (vs. zero) %-of-BMI_{95} improvement.
[a]Models, clustered by clinic, account for the hierarchical correlation structure among repeated observations. All covariates were forced into the multivariable model.
[b]Predictor or covariate at first (index) visit in visit-to-visit interval.
[c]Prescribed medicine within 30 days of second (follow-up) visit in visit-to-visit interval.
[d]Double-digit decimal estimates reported. Estimates significant (95% CI excluded 1.00), when additional digits were included, are indicated by bolding to depict adjustment variables with $p<0.05$ in analyses. For example, for the likelihood of %-of-BMI_{95} improvement associated with index visit %-of-BMI_{95}, the crude OR=1.007 (95% CI=1.005, 1.008), and the AOR=1.005 (95% CI=1.004, 1.007). For black race, the adjusted likelihood of %-of-BMI_{95} improvement was 0.912 (95% CI=0.829, 1.003).
%-of-BMI_{95}, percentage of BMI_{95}.

children improve their weight.[3,16] Thus, past studies have supported the hypothesis that increasing pediatrician communication about a child's unhealthy weight and risk for or presence of obesity comorbidities would be expected to increase parental motivation to make behavioral changes.[10,33,34] The present findings build on past work, showing that a clinician's attention to high BMI in combination with medical risk is associated with significant improvement in children's relative weight.

Forty-five percent of children with overweight and obesity overall and 11% with obesity Class 3 lacked EHR evidence of attention to high BMI alone or in combination with medical risk assessment at well-child visits—a prevalence similar to estimates from previous studies using various data sources and study designs.[3,12,13] For example, in surveys, pediatric providers have reported assessing BMI at 50%–60% of visits, and, in visits directly audio-/video-recorded by the research team,

providers discussed longitudinal weight management plans in 65% of visits.[3,12,13,35] Therefore, combining diagnosis codes with other EHR information relevant to addressing high BMI in primary care (e.g., orders for referrals, medications, and laboratories) resulted in a prevalence estimate of attention to high BMI comparable to estimates from studies that did not rely on EHR data. Moreover, the EHR (versus surveys and videotaping) offers the dual opportunity of detecting attention to BMI/comorbidities and using the information to intervene through use of alerts and EHR-enabled decision support.

A novel study finding is that significant proportions of children with overweight or obesity are prescribed medicines known to impact weight as a side effect. Being prescribed these medicines is associated with the likelihood of %-of-BMI_{95} improvement. Because, in general, many children receive prescription medicines (1 in 5 children per month, according to population-based data[36]), providers might consider the weight impact of prescription medicines, especially for patients with overweight and obesity. Although providers should prescribe a medicine only for its U.S. Food and Drug Administration–approved indication (e.g., migraine), they might consider the weight-specific side effect profile in selecting a medicine within a therapeutic class. This study looked at whether medicines had any evidence of weight impact. Future work will analyze the amount of weight impact from the medicines identified herein.

Study strengths include the large sample size, racially/ethnically diverse population, a variety of clinic types, and assessment and identification of medications impacting weight. Another strength is the construction and use of widely recommended clinician behaviors. Until now, few data existed to support an association of guideline-recommended clinician behaviors and weight status improvement. Whereas previous studies of primary care interventions bundled clinician behaviors into multilevel interventions,[37,38] these findings provide estimates of incremental associations of attention to high BMI/comorbidities with weight status improvement.

Limitations

Certain study limitations should be noted. Because the population consisted of children aged 6–12 years from a single geographic location receiving care at clinics using EHRs, findings may not necessarily generalize to children in other age groups, geographic areas, followed at clinics without EHRs, or lacking primary care. The reliance on EHR evidence limited the author's ability to determine attribution of both attention to BMI/comorbidities and length of time between visits; each could have been initiated by clinicians or patients and families. Additional limitations are the potential for residual confounding from unmeasured variables (e.g., interaction of parent and provider BMI) and misclassification bias of the exposure (e.g., lipid screening alone to denote comorbidity screening might lead to differential misclassification in children aged 9–11 years for whom the test was ordered for universal cholesterol screening). Recognizing the potential for such misclassification to dilute the impact of comorbidity screening on weight status improvement, attention to comorbidities required that children have attention to BMI and 2 or more obesity-related laboratory tests on the same day. Finally, although this retrospective study identified specific provider behaviors associated with weight status improvement, effects of these behaviors on weight status improvement merit examination through prospective trials.

CONCLUSIONS

This is the first study, to the authors' knowledge, showing that performance of widely recommended weight management clinician behaviors in primary care is associated with weight status improvement in children aged 6–12 years with overweight and obesity. The findings suggest that enhancing adoption of these guideline-informed, evidence-based clinician behaviors may prove useful in the weight management of children with overweight and obesity.

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CBT designed the study, obtained funding, supervised EHR data collection, assisted with analysis and interpretation of data, and drafted the manuscript; SEB assisted with the study design,

analysis, clinical interpretation of data, and critically revised the manuscript; DBS assisted with analysis and interpretation of data, and critically revised the manuscript; BA assisted with the study's EHR data algorithm development, refinement, building analytic variables, methods communication (ensuring section accurately depicts study protocol and analysis), and critically revised the manuscript; JS oversaw data management, work performed by BA, and critically revised the manuscript; CA and SZ assisted with the study's statistical design and oversaw analysis of the data; GF oversaw the initial study design, assisted with interpretation of data, and critically revised the manuscript; CSS oversaw the final study design, assisted with analysis and data interpretation, and critically revised the manuscript. All authors approved the final manuscript as submitted.

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SUPPLEMENTAL MATERIAL

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