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Impact of Electronic Health Record Clinical Decision Support on the Management of Pediatric Obesity

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Abstract

Clinicians vary significantly in their adherence to clinical guidelines for overweight/obesity. This study assessed the impact of electronic health record–based clinical decision support in improving the diagnosis and management of pediatric obesity. The study team programmed a point-of-care alert linked to a checklist and standardized documentation templates to appear during health maintenance visits for overweight/obese children in an outpatient teaching clinic and compared outcomes through medical record reviews of 574 (287 control and 287 intervention) visits. The results demonstrated a statistically significant increase in the diagnosis of overweight/obesity, scheduling of follow-up appointments, frequency of ordering recommended laboratory investigations, and assessment and counseling for nutrition and physical activity. Although clinical guideline adherence increased significantly, it was far from universal. It is unknown if modest improvements in adherence to clinical guidelines translate to improvements in children's health. However, this intervention was relatively easy to implement and produced measurable improvements in health care delivery.

Keywords

obesity, decision-support system, medical informatics, quality of care, child, adolescent

Obesity is the most significant preventable health condition affecting children in the United States, with approximately 32% of children and adolescents being overweight or obese.[1] The Centers for Disease Control and Prevention defines overweight in children as body mass index (BMI) between the 85th and 94th percentile for age and sex. Obesity is defined as BMI at or more than the 95th percentile for age and sex. It is important to identify children whose BMI is greater than the 85th percentile because high BMI in children and adolescents can result in complications such as dyslipidemia and high blood pressure and increase future risk of obesity in adulthood.[2 3]

Expert recommendations in the United States advise that clinicians evaluate children's growth using BMI percentile and provide counseling on nutrition and physical activity.[4] Even though these practices are now nationally endorsed Healthcare Effectiveness Data and Information Set quality measures, there is significant variation in clinician adherence.[5] Pediatric obesity and overweight are underdiagnosed in clinical practice, and nutrition and physical activity counseling are not universally provided for obese and overweight children.[6]

The most feasible and effective strategies to change outpatient practice utilize a multifaceted systems approach to reduce barriers that prevent health care professionals from changing practice patterns.[7-9] One component of this approach includes provider-level interventions (eg, counseling algorithms) and office-level systems supports (eg, reminder systems). Health care providers have recently focused increasing attention on improving clinical outcomes using electronic systems. Clinical decision-support tools, such as reminders within electronic health records (EHRs) at the point of care, have improved adherence to preventive recommendations for childhood vaccination, breast cancer screening, colorectal cancer screening, and cardiovascular risk reduction.[10,11] As the adoption of EHRs expands, computer-based clinical decision support has the potential to change clinician behavior and improve the detection and management of obesity and overweight.

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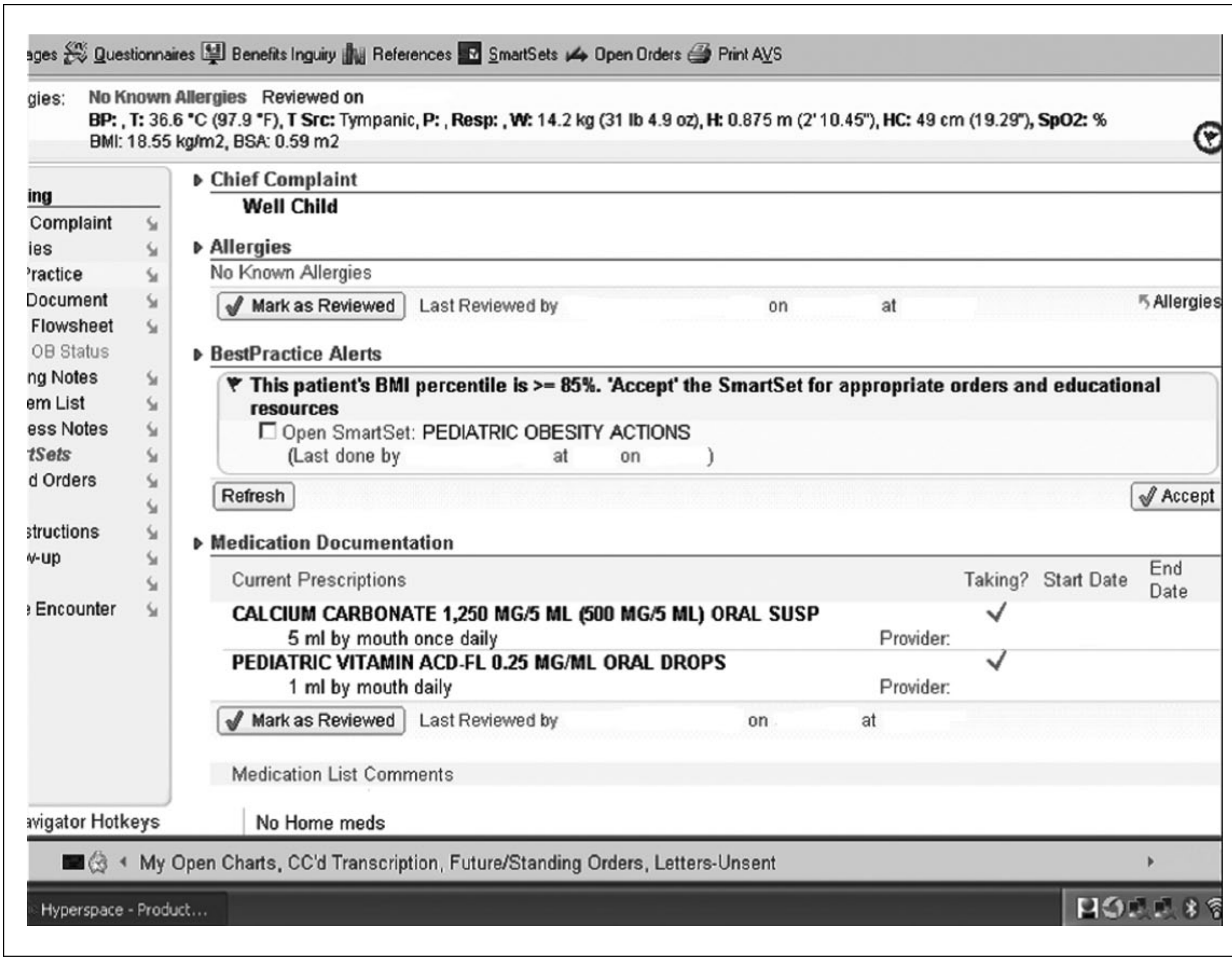

Figure 1. Screenshot of electronic health record alert.

The authors' previous study indicated that passive changes, such as automatic calculation and presentation of BMI within an EHR, were insufficient to result in systematic improvements in assessment and management of pediatric overweight and obesity.[12] The goal of the present study was to test the hypothesis that clinical decision support at the point of care—specifically an alert for high BMI, a checklist, and standardized documentation templates—increases adherence to clinical recommendations for overweight and obesity.

Methods

Setting

Approximately 36 pediatric house staff and 12 attending pediatricians at the University of California Davis Health System's outpatient clinic see approximately 12 000 children and adolescents annually for well-child care. The ambulatory EHR, EpicCare (Epic Systems Corporation, Verona, WI), was implemented in this practice in November 2006.

Study Design and Patient Population

The University of California Davis' institutional review board approved this study. Based on definitions published by the Centers for Disease Control and Prevention, the study team programmed an alert for BMI at or more than the 85th percentile for age and sex that appeared prominently at the point of care during every well-child visit for children 2 to 18 years old (Figure 1) along with a checklist (Figure 2) and standardized documentation templates. Standardized documentation templates were automatically populated with patient-specific BMI and BMI percentile data and also included fields for clinicians to enter diet and activity information consistent with clinical guidelines.[13] The study team conducted a 1-hour training session for clinicians prior to implementing the intervention, which included an update on national recommendations for the evaluation and management of pediatric obesity, information on the alert, as well as the associated clinical decision-support tools. The research team was available to address questions by telephone.

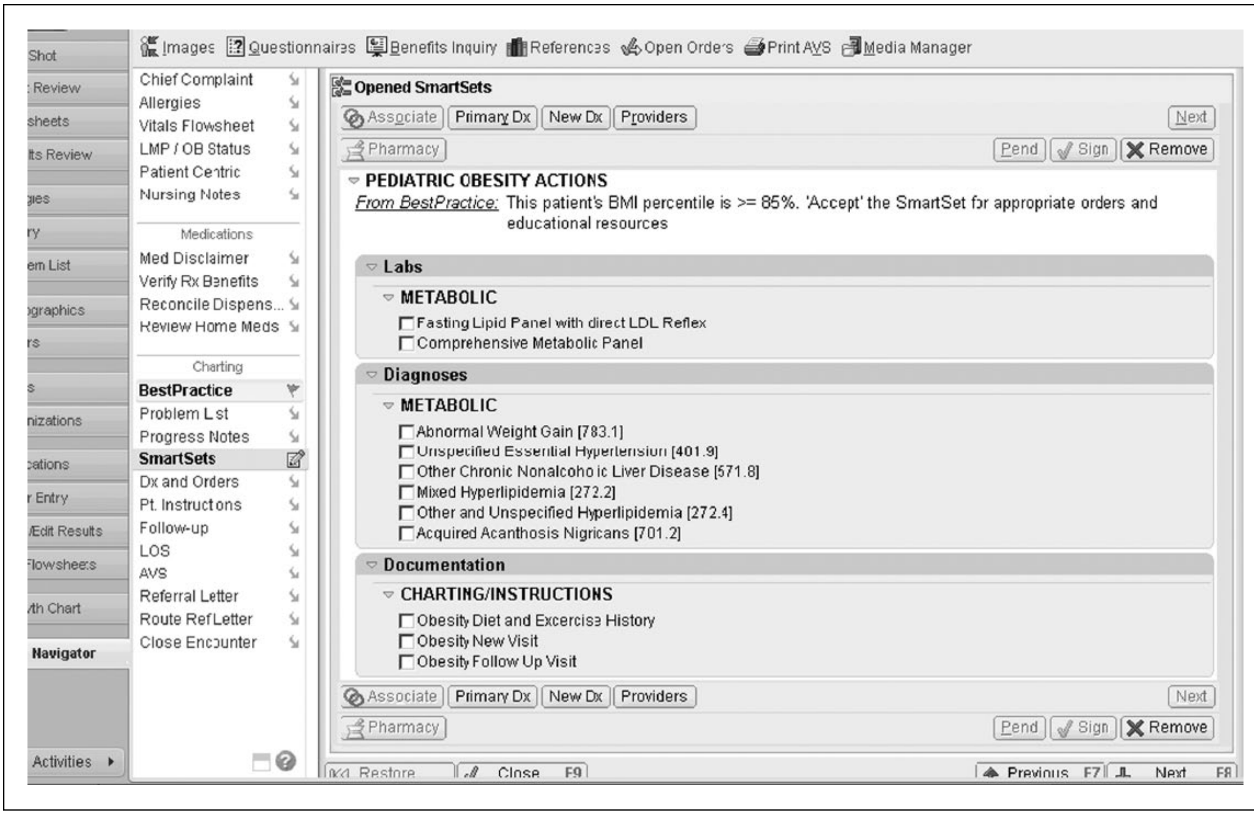

Figure 2. Screenshot of checklist.

Intervention and control periods lasted 9 months each: October 1, 2009, to June 30, 2010, and October 1, 2008, to June 30, 2009, respectively. The alert appeared only during health maintenance visits and did not appear if the child already had a documented diagnosis of obesity in the past or had an order placed within the past 12 months for obesity counseling or treatment. The alert did not interfere with existing work flow, and functions were not incorporated to force clinicians to adhere to the alert.

Sample Size Calculation

Based on the effectiveness of clinical alerts in similar studies, the present study was designed to have 80% power to detect at least 12% difference in rates of change between the control and intervention groups.[10,14-17] The calculated sample size required 288 children per group, but patient clustering within clinicians would have reduced the power of the analysis. To balance this reduction in power, the study team took advantage of the pre-post study design and devoted half of the pretest sample to children who also had posttest visits in the study period. This approach provided a substantial increase in power by using analytical methods that account for repeated measures. The study team chose not to rely solely on children with visits in both time periods in case there were systematic differences between children who received well-child care with regularity and other children. Patients of the 2 pediatricians on the research team were excluded; 12 patients and 30 patients, respectively. The final sample included 574 observations drawn from 287 control and 287 intervention visits. These observations included 142 children with both control and intervention visits and 290 children with only a single control or intervention visit.

Outcome Measures

The study team tested the effect of the intervention on (1) the diagnosis of overweight/obesity, (2) assessment of risk factors and whether counseling for nutrition and physical activity was delivered, (3) referral to a dietitian, (4) laboratory evaluation, and (5) scheduling of a follow-up visit for weight management. The first 2 outcome measures served as an assessment of whether the intervention increased clinicians' adoption of national recommendations for childhood obesity. Outcomes were measured by medical record review. Two study team members (US, JB) independently reviewed an initial subset of 20 medical records, compared and reconciled their

Table 1. Study Outcomes Based on a Rubric of Assessment, Identification of Risk Factors, and Provision of Counseling.[a]

Assessment	Risk Factor	Counseling	Outcome
Yes	Yes	Yes	Adequate (1)
Yes	No	No	Adequate (1)
Yes	No	Yes	Adequate (1)
Yes	Yes	No	Inadequate (0)
Yes	Unclear	No	Missing (NA)
Yes	Unclear	Yes	Adequate (1)
No	NA	Yes	Inadequate (0)
No	NA	No	Inadequate (0)

[a]Assessment and counseling outcomes were classified as adequate or inadequate according to the following rubric. Assessment of a risk factor was required in order to be considered adequate. If a risk factor was present and no counseling was provided, the assessment/counseling outcome was considered inadequate. In cases where assessment was performed and the presence of a risk factor was unclear from the notes, the outcome was considered adequate if counseling was performed. If counseling was not performed, the outcome was classified as missing.

individual assessments, and developed a codebook that guided further medical record reviews.

The documentation of assessment of obesity risk factors and subsequent counseling was classified as either adequate or inadequate using the rubric in Table 1. The study team evaluated counseling on the following nutrition-related topics: fruits/vegetables, fast food, family meals, breakfast intake, sugary drinks, and other nutrition-related topics. Because it is unlikely that clinicians had adequate time to evaluate and provide in-depth counseling on all 6 topics during a single visit, a score for each topic (adequately assessed and counseled = 1; inadequately assessed and counseled = 0) was averaged across all topics (Cronbach $\alpha = .65$). In the 1 case that >2 components of the nutrition assessment/counseling score were missing, the entire nutrition assessment/counseling score was classified as missing. Assessment and counseling on screen time (television viewing and video game use) and physical activity also were classified as either adequate or inadequate but were assessed individually. Assessment/counseling scores for screen time and physical activity were classified as missing for 12 and 11 individuals, respectively.

Covariates

Children's age, BMI percentile, race/ethnicity, sex, insurance status, presence of chronic diseases, and the level of training of the clinician were considered as covariates. For the purpose of this study, chronic diseases were defined as those likely to affect growth assessment and counseling, such as diabetes, cerebral palsy, congenital heart disease, cystic fibrosis, and congenital anomalies.

Statistical Analysis

Statistical analysis using SAS Version 9.3 (SAS Institute Inc., Cary, NC)[18] characterized and compared the sample during control and intervention periods in terms of child and clinician characteristics as well as in terms of primary and secondary outcomes.

The study team explicitly accounted for correlation related to clustering by clinician and repeated measures on one third of the children in all analyses. Because child-level categorical outcomes were fixed, these outcomes were tested for differences between the preintervention and postintervention phases, excluding individuals who were present at both time points with Wald log-linear χ^2 tests, with clinicians specified as clusters. Continuous, potentially time-varying, child-level variables (BMI percentile and age) were tested for pre-post differences using mixed models with providers specified as repeated and random intercepts for patients. The study team looked for possible differences in the distribution of clinician type (resident by year of training, nurse practitioner, or attending physician) between control and intervention phases by testing with a survey-adjusted Wald log-linear χ^2 test. Additionally, the team investigated the possibility of a trend in clinician experience level between the 2 time points by a survey-adjusted *t* test. Outcomes were evaluated with mixed-effects linear regression models, including random intercepts for children and specifying clinicians as repeated. Sandwich variance estimators were used to robustly estimate standard errors for binary outcomes using a linear model.[19] The resulting estimates can be viewed as proportions. Covariates were included in the final model for each outcome if the inclusion of a given covariate affected the estimate for control/intervention change in a bivariate model by more than 10% or if the covariate was determined to be unbalanced between the control and intervention study periods (Table 2).

Results

Study Population

The sample included 432 overweight/obese children with a total of 574 visits, 287 in each study period (Table 2). Both the control and intervention study periods included slightly more boys than girls, with most children having public health insurance. A small proportion of children in each period had a chronic disease. Patient characteristics remained stable across the control and intervention samples, except for age. The significant difference in the age distribution between the 2 time periods was expected because a third of the children were assessed in the intervention period a year after being included in the control

Table 2. Patient and Clinician Characteristics for the Pre-alert Time Period (October 1, 2008, to June 30, 2009) and the Post-alert Time Period (October 1, 2009, to June 30, 2010).

		Pre-alert, n (%)	Post-alert, n (%)	*P* Value
n		287	287	
Sex	Male	153 (53.3)	158 (55.1)	.57
	Female	134 (46.7)	129 (45.0)	
Race/Ethnicity	White	61 (21.3)	51 (17.8)	.86
	Black	89 (31.0)	104 (36.2)	
	Hispanic	93 (32.4)	100 (34.8)	
	Other	44 (15.3)	32 (11.2)	
Health insurance	Public	230 (80.1)	226 (78.8)	.45
	Private	55 (19.2)	60 (20.9)	
	None/Unknown[a]	2 (0.7)	1 (0.4)	
Chronic disease	Yes	18 (6.3)	23 (8.0)	.79
	No	270 (93.8)	265 (92.0)	
Clinician type	PL1	53 (18.5)	46 (16.0)	.47
	PL2	37 (12.9)	73 (25.4)	
	PL3	64 (22.3)	66 (23.0)	
	PNP	11 (3.8)	11 (3.8)	
	Faculty	122 (42.5)	91 (31.7)	
		Mean (SD)	Mean (SD)	*P* Value
Age (years)		8.0 (4.4)	8.8 (4.6)	<.0001
BMI percentile		94.9 (4.1)	95.1 (4.2)	.27

Abbreviations: BMI, body mass index; SD, standard deviation.
[a]Not included in test, classified as missing for purposes of analyses.

period. The trend test for level of clinician experience was nonsignificant ($P = .20$). There were no statistically significant differences in age, sex, presence of chronic disease, insurance type, race/ethnicity, and BMI percentile between children who had 1 and 2 visits.

Outcome Measures

Changes in key outcome measures are graphically represented in Figure 3. Following the intervention, diagnosis of overweight/obesity increased from 40% to 57% ($P < .001$). There was no significant increase in the proportion of patients referred to a dietitian or weight management program (13% in both periods). The proportion of children for whom laboratory investigations for evaluation of dyslipidemia and diabetes were ordered increased from 17% to 27% ($P = .001$). The proportion of children who were scheduled for follow-up appointments for overweight/obesity increased from 24% to 42% ($P < .001$).

For process outcomes, the reported estimates are the proportion of visits during which a diagnosis of obesity was made, a referral to a dietitian was given, laboratory evaluations were performed, and a follow-up visit with the clinician for weight management was scheduled. The nutritional assessment/counseling score is the proportion of nutritional counseling topics that were assessed and counseled adequately (out of 6). The reported physical activity and screen time estimates are the proportion of visits in which these 2 topics were assessed and counseled adequately. All models were adjusted for age (centered); the model for screen time also adjusted for BMI percentile (centered). Outcomes marked with an asterisk indicate significant change.

Risk Factor Assessment and Counseling

The study team classified assessment and counseling as adequate (1) or inadequate (0) based on the rubric in Table 1. The 6 nutrition topics were combined into a single score ranging from 0 to 1 for each visit. The average nutritional assessment and counseling score improved from 0.28 to 0.39 ($P < .001$), which corresponds to an increase in assessment and counseling from 28% to 39% for the 6 topics. Physical activity assessment and counseling increased from 28% to 41% ($P < .001$). There was no significant increase in assessment/counseling of screen time (29% intervention, 32% control). Assessment of risk factors without documentation of counseling occurred in 11 visits for physical activity and 12 visits for screen time and did not occur at all for nutrition.

Because age was not balanced between the preintervention and postintervention periods, it was used as a

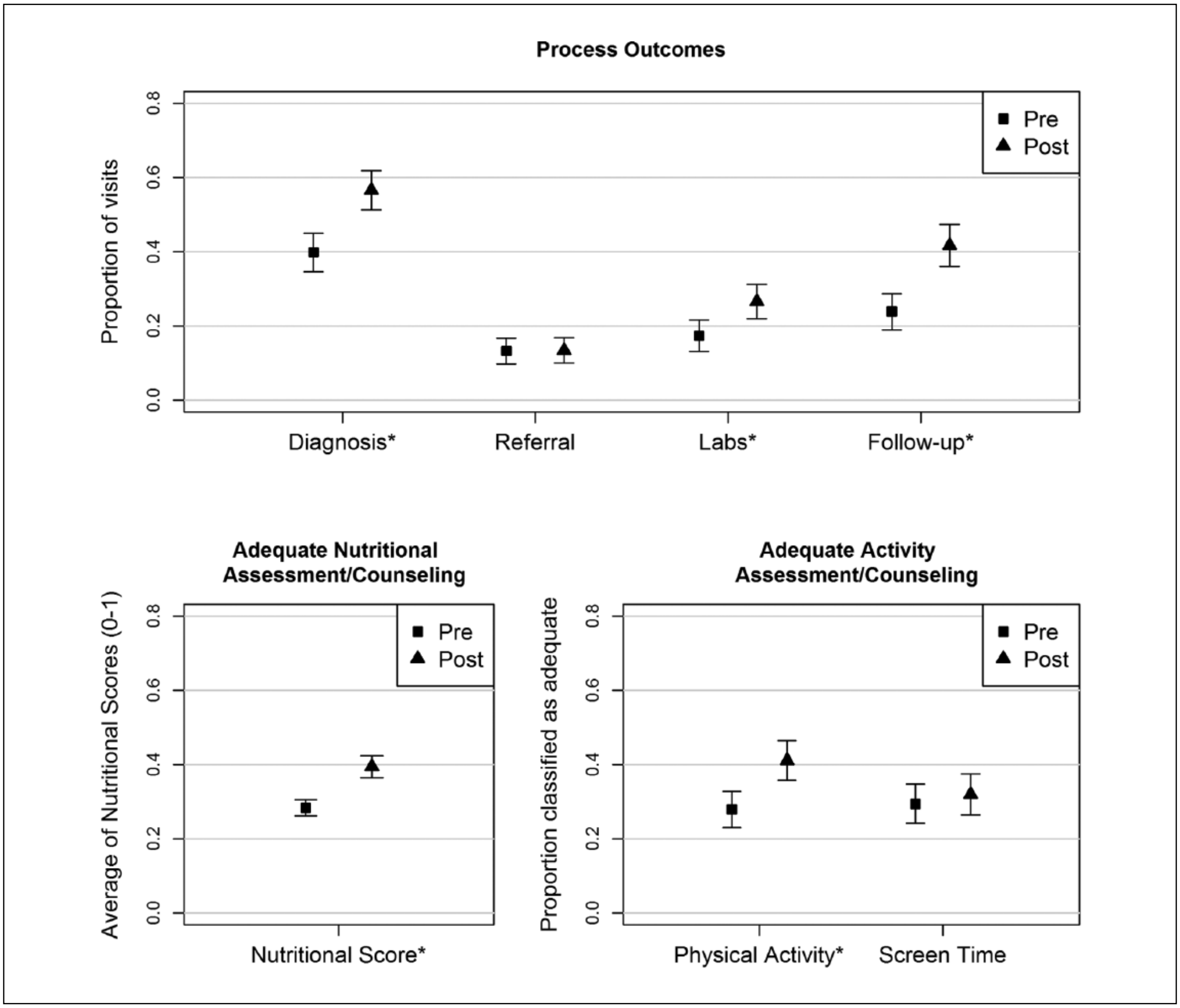

Figure 3. Adjusted preintervention and postintervention estimates of all primary outcomes (bars represent 95% confidence intervals).

potential confounder in all models. Age was a significant predictor for all process outcomes as well as counseling for physical activity and indicated that older children were more likely to receive these services ($P \leq .001$). BMI percentile was included as a confounder in the screen time model because its inclusion changed the primary estimate by more than 10%. In this model, higher BMI percentile was associated with an increased prevalence of screen time counseling ($P = .004$).

Discussion

This study shows that a quality improvement intervention focusing on EHR-based clinical decision support was modestly effective in increasing adherence to clinical recommendations for pediatric overweight and obesity. Clinical care significantly improved following the intervention. However, adherence was far from universal.

As EHRs become more common, such systems may increase the timely delivery of evidence-based practices for pediatric obesity. Based on current national clinical recommendations, the EHR-based clinical decision support in the present study aimed to improve recognition of and counseling for pediatric overweight/obesity.[4] Although it is true that effective pediatric weight management strategies remain poorly defined, this intervention is an important first step in the clinical care of overweight/obesity. The study team acknowledges the possibility that secular trends related to an increased awareness of and national focus on childhood obesity over the 2 study years may have affected the study results. However, the team anticipates that this effect would be unlikely to change the results significantly because published literature demonstrates that awareness of clinical guidelines is insufficient to change clinician behavior without additional system-level interventions.[7-9]

An early meta-analysis of randomized controlled trials assessing computer-based clinical reminders for preventive care found that they improved preventive practices for vaccinations, breast and colorectal cancer screening, and cardiovascular risk reduction.[11] A later systematic review of trials studying the effectiveness of both paper-based and computer-generated physician reminders on the delivery of preventive care measures showed that the average increase ranged from 12% to 14%, with reminders for cardiac care and smoking cessation interventions being the most successful.[15] In a cluster randomized controlled trial of an EHR-based reminder to improve tobacco treatment in 26 primary care practices, Linder et al[20] demonstrated that the intervention significantly improved smoking status documentation from 37% to 54% in intervention practices compared with an increase from 35% to 46% in control practices. The reminder was displayed prominently at the point of care and resulted in an increase in counseling assistance to smokers, although it did not increase the prescription of smoking cessation medication. Similarly, the present study of an EHR-based alert utilized point of care and linked-order entry features that improved overweight/obesity assessment, evaluation, and counseling; however, it did not affect referral decisions.

More frequently than not, implementation of computerized reminder systems results in only modest improvements in care for primary prevention measures, such as immunizations, despite significant published scientific evidence and widespread support among clinicians regarding their effectiveness. For example, Fiks et al[10] assessed the impact of EHR-based alerts on rates of routine childhood immunization in urban primary care centers. Alert implementation was associated with increases in captured immunization opportunities from 78% to 90% at health maintenance visits and improvements in immunization rates at 2 years of age from 82% to 90%. Fiks et al[21] then evaluated the impact of influenza vaccine clinical alerts on missed opportunities for vaccination and on influenza immunization rates for children and adolescents with asthma at 20 primary care sites, as part of a cluster-randomized trial. Captured vaccination opportunities increased from 14% to 18% at intervention sites and from 13% to 16% at control sites—a 0.3% greater improvement. Influenza vaccination rates improved by 3.4% more at intervention sites than at control sites. Thus, computer-based clinical reminders remain modestly effective in increasing childhood immunizations rates whether applied to targeted disease-specific populations or not.[22]

Rates of adherence differ greatly for various clinical guidelines. It is possible that this variation depends on factors such as clinicians' belief in the effectiveness or scientific merit of the intervention, design characteristics of the decision support, and contextual issues. For example, a multiphysician practice in Australia demonstrated generally low and variable adherence to well-established preventive measures, ranging from 1.5% for tetanus immunization to 27% for influenza immunization, possibly reflecting clinicians' belief in certain preventive measures. An EHR alert for preventive care in this practice resulted in a significant increase in tetanus immunization but an unexpected decline in influenza immunization, supporting the findings of the present study that clinicians may not adhere to clinical guidelines even when these are incorporated into point-of-care clinical decision-support tools.[23] Similarly, an EHR reminder system designed to improve diabetes and coronary artery disease care demonstrated variable and limited baseline adherence rates to evidence-based guidelines; specifically, rates were highest for annual cholesterol monitoring, yet were lowest for statin use. Although the intervention increased the overall odds of patients receiving recommended care, the uptake of individual reminders mirrored baseline adherence practices.[24]

Clinical decision-support tools vary considerably, from simple alerts to complex patient-derived care algorithms, each affecting clinician behavior differently. One systematic review showed that point-of-care reminders generally were associated with small-to-modest changes in clinician behavior, although large improvements did occur with simple reminders that lacked multifaceted cointerventions.[17] Another systematic review showed that most computerized drug alerts and prompts improved prescribing behavior, with some additionally reducing medical error rates.[25] Finally, an important concern that may specifically affect adherence to interventions in primary care for childhood obesity is the dearth of high-level evidence for their effectiveness.[26]

A common finding in all the published research studies mentioned, as well as in the present study, is that, on their own, computerized clinical decision-support tools do not eliminate deviation from clinical guidelines and that multifaceted approaches to increase guideline implementation may be required. Additionally, it is possible that over time, clinicians may become acclimated to such alerts and may choose to ignore them, particularly if the number of alerts becomes burdensome or intrusive.[27] The study team's intervention included a 1-hour training on the computerized clinical decision-support tools prior to implementation. It is possible that more interactive, repeated periodic training during the intervention period might have enhanced the effectiveness of these tools.[28] Although the study team's computerized clinical decision-support tools did improve adherence to clinical recommendations for pediatric overweight and obesity, future studies need to address strategies to further enhance the effectiveness of similar interventions.

One limitation of this study is that some of the outcome measurements were dependent on the documentation of clinician behavior within medical records. The study team's previous research demonstrates that assessing clinician documentation may underestimate the true frequency of these behaviors, particularly for outcomes related to discussion.[29] The team also was unable to classify risk factor assessment and counseling for visits during which risk factor assessment occurred but the presence of a risk factor was unclear and counseling was not delivered, although this accounted for a very small number of observations—specifically, 5 for nutrition, 15 for physical activity, and 15 for screen time. Although the study team accounted for correlation related to clustering by physician, the team was unable to account for varying depth of relationship between parents and providers. It is possible that siblings have been included in the samples and any arising correlation has not been accounted for. It is possible that parents who brought in multiple children to the visit discussed physical activity and nutrition topics with the clinician for a child not included in the sample. These discussions could have been reflected in the EHR for children included in the study, thus overestimating counseling. Another limitation is the focus on clinician-level process measures. It remains to be seen whether these and similar actions taken by clinicians translate into improved patient outcomes. For example, in an analysis of the effect of EHR prompts and reminders on the quality of care for diabetes, researchers found that EHR use was associated with improvements in process measures—namely, glycosylated hemoglobin and low-density lipoprotein testing—but not with improved metabolic control.[30] On the other hand, a computer reminder for brief alcohol counseling in 8 Veterans Administration clinics was associated with a decrease in alcohol consumption among patients.[31]

These limitations notwithstanding, the present study demonstrates that computerized clinical decision-support tools—specifically, a clinical alert linked to a standardized checklist and documentation templates—can improve documented assessment and counseling for pediatric overweight and obesity at the point of care. Although it is unknown if modest improvements in adherence to clinical guidelines translate into improvements in children's health, this intervention is relatively easy to implement and produces measurable improvements in adherence to clinical recommendations. The findings, however, support other studies assessing preventive care measures, such as immunizations and cancer screening, in that EHR-based clinical decision-support tools by themselves fall short in bridging the gap between actual and recommended practices for pediatric obesity prevention and management. The study team foresees a more realistic role for EHR-based reminders as a component of comprehensive multifaceted interventions within primary care. Although EHRs have the potential to inform clinical practice and to allow a clinician to perform tasks with a consistency that previously was difficult to achieve, the epitome of EHR alerts remains elusive.

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Declaration of Conflicting Interests

The authors declared no conflicts of interest with respect to the research, authorship, and/or publication of this article.

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