

Clinical Effectiveness of the Massachusetts Childhood Obesity Research Demonstration Initiative Among Low-Income Children

Elsie M. Taveras^{1,2}, Meghan Perkins¹, Shikha Anand³, Jennifer A. Woo Baidal^{1,4}, Candace C. Nelson⁵, Neil Kamdar¹, Jo-Ann Kwass⁶, Steven L. Gortmaker⁷, Jessica L. Barrett⁷, Kirsten K. Davison^{2,7}, and Thomas Land⁵

Objective: To examine the extent to which a clinical intervention resulted in reduced BMI z scores among 2- to 12-year-old children compared to routine practice (treatment as usual [TAU]).

Methods: The Massachusetts Childhood Obesity Research Demonstration (MA-CORD) project is a multifaceted initiative to prevent childhood obesity among low-income children. At the federally qualified community health centers (FQHCs) of two communities (Intervention Site #1 and #2), the following were implemented: (1) pediatric weight management training, (2) electronic decision supports for clinicians, (3) on-site Healthy Weight Clinics, (4) community health worker integration, and (5) healthful clinical environment changes. One FQHC in a demographically matched community served as the TAU site. Using electronic health records, we assessed BMI z scores and used linear mixed models to examine BMI z score change over 2 years in each intervention site compared to a TAU site.

Results: Compared to children in the TAU site ($n = 2,286$), children in Intervention Site #2 ($n = 1,368$) had a significant decline in BMI z scores following the start of the intervention (-0.16 units/y; 95% confidence interval: -0.21 to -0.12). No evidence of an effect was found in Intervention Site #1 ($n = 111$).

Conclusions: The MA-CORD clinical interventions were associated with modest improvement in BMI z scores in one of two intervention communities compared to a TAU community.

Obesity (2017) 25, 1159-1166. doi:10.1002/oby.21866

Introduction

After increasing steadily for three decades, the national childhood obesity prevalence in the United States appears to have leveled off among children less than 12 years of age (1). However, childhood obesity prevalence remains at historically high levels and progress has not been equitably distributed. Racial and ethnic minority children and children from low-income families and neighborhoods continue to bear a disproportionate share of the burden of obesity (2,3). In 2011, in an effort to reduce the substantial disparities in obesity prevalence among its underserved pediatric populations, Massachusetts launched the MA Childhood Obesity Research Demonstration (MA-CORD) project, a multifaceted initiative funded by the Centers

for Disease Control and Prevention (4) to prevent and manage obesity among children ages 2 to 12 years living in low-income communities (5). The study implemented evidence-informed interventions across several sectors working with low-income children, including pediatric clinical care delivered at federally qualified community health centers (FQHCs) (5,6).

Health centers in low-income communities are well positioned to have an impact on childhood obesity. FQHCs often serve as patient-centered medical homes offering valuable opportunities for screening and detection of overweight and obesity, as well as services to manage the subsequent course of health and disease for children

¹ Division of General Academic Pediatrics, Department of Pediatrics, MassGeneral Hospital for Children, Boston, Massachusetts, USA. Correspondence: Elsie M. Taveras (elsie.taveras@mgh.harvard.edu) ² Department of Nutrition, Harvard T.H. Chan School of Public Health, Boston, Massachusetts, USA ³ National Institute for Children's Health Quality, Boston, Massachusetts, USA ⁴ Division of Pediatric Gastroenterology, Hepatology, and Nutrition, Department of Pediatrics, Columbia University Medical Center, New York, New York, USA ⁵ Office of Data Management and Outcomes Assessment, Massachusetts Department of Public Health, Boston, Massachusetts, USA ⁶ Bureau of Community Health and Prevention, Massachusetts Department of Public Health, Boston, Massachusetts, USA ⁷ Department of Social and Behavioral Sciences, Harvard T.H. Chan School of Public Health, Boston, Massachusetts, USA.

Funding agencies: This study was supported by the Centers for Disease Control and Prevention (CDC) National Center for Chronic Disease Prevention and Health Promotion (Award no.: U18DP003370). Dr. Taveras is supported by grant K24 DK10589 from the National Institute of Diabetes and Digestive and Kidney Diseases. This work is solely the responsibility of the authors and does not represent the official views of the CDC or any of the other funders.

Disclosure: The authors declared no conflicts of interest.

Clinical trials registration: ClinicalTrials.gov identifier NCT02110615.

Received: 13 December 2016; **Accepted:** 9 March 2017; **Published online** 27 June 2017. doi:10.1002/oby.21866

diagnosed with obesity (7). The increasing use of electronic health records in community-based health centers has been shown to improve the quality of care for children with obesity and to accelerate the use of Expert Committee evidence on obesity screening and management practices by primary care providers (8,9). Mounting evidence also suggests that community health workers (CHWs), who are increasingly embedded in chronic disease prevention teams at FQHCs, can link clinical and community systems and programs and support family behavior change for obesity management (10-13).

This manuscript reports the main outcomes of a quasi-experimental trial examining the extent to which a comprehensive clinical intervention delivered at two FQHCs as part of MA-CORD improved BMI outcomes among low-income children ages 2 to 12 years. We hypothesized that children receiving care at the two intervention FQHCs would demonstrate improved age- and sex-specific BMI *z* scores over a 2-year period compared to those receiving routine care (treatment as usual [TAU]) at a FQHC of a demographically matched Massachusetts community.

Methods

Study overview

We conducted a quasi-experimental trial at two FQHCs—one in each of two Massachusetts communities selected to participate as intervention sites for MA-CORD based on size, per capita income, and prevalence of childhood overweight and obesity. The conceptual framework, intervention design, and evaluation methods for the larger MA-CORD initiative have been described in detail (4-6). Briefly, MA-CORD spanned several sectors including FQHCs; the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC); public elementary and middle schools; after-school settings; and the broader community. In each sector in both communities, we implemented evidence-based programs to promote childhood obesity prevention.

Here we summarize the clinical intervention components that were part of MA-CORD and their effectiveness. At the two intervention FQHCs, we implemented a systematic, comprehensive clinical intervention. One FQHC in a demographically matched Massachusetts community served as the comparison. The primary outcome was improvement in child age- and sex-specific BMI *z* score over a 2-year intervention period using electronic health records from the two intervention and one TAU FQHCs. Secondary outcomes included changes in BMI *z* score and percent of the 95th percentile (BMI_{p95}) among children referred to the Healthy Weight Clinics at the intervention FQHCs.

Eligibility and recruitment

The study protocol was approved by the Massachusetts Department of Public Health human subjects committee. All well children aged 2 to 12 years receiving care at the three FQHCs and residing in the community were eligible for the longitudinal analyses of BMI changes. Children with severe chronic health conditions (e.g., congenital and chromosomal anomalies) were excluded. Children with $BMI \geq 85$ th percentile were eligible for referral to the Healthy Weight Clinics. We received a waiver of informed consent from the Massachusetts Department of Public Health to use longitudinal electronic health record data.

Clinical intervention

Evidence-informed interventions were implemented across both intervention FQHCs (Figure 1) (14-16). Intervention components aimed to improve primary and secondary prevention of childhood obesity and included (1) advanced training to FQHC staff on clinical quality improvement and obesity prevention, assessment, and management; (2) computerized, point-of-care decision support tools for clinicians on obesity management; (3) implementation of multidisciplinary weight management programs within the FQHCs, e.g., Healthy Weight Clinics; (4) integrating CHWs into the primary care and Healthy Weight Clinic teams; and (5) FQHC environmental changes to support behavior change modification.

Staff training

Staff from the two intervention FQHCs received advanced training on obesity prevention, assessment, and management through a combination of a modified Breakthrough Series Collaborative (17) and individualized team coaching to assist with implementation of evidence-based practices (5). Participants included a physician champion, clinical staff such as nurses or medical assistants, administrative leaders, CHWs, and representatives from local health and wellness coalitions. Training included (1) quality improvement methods; (2) methods of encouraging health behavior change, including motivational interviewing; (3) best practices in treating childhood obesity; and (4) Be Our Voice (18) advocacy training, which engages and trains clinicians to be advocates of children in the fight against childhood obesity. Full-day live learning sessions were held every 6 months, supplemented by monthly interactive webinars and individualized coaching.

Point-of-care clinical decision support tools

To support evidence-based management of pediatric obesity, existing electronic health records at each health center were modified to deploy a computerized, point-of-care, decision support alert to pediatricians at the time of a well-child care visit for a child with $BMI \geq 85$ th percentile. The alert, which has been shown to be effective in improving quality of care for overweight children (8,9), contained links to the child's growth chart and a link to a prepopulated, standardized note specific for obesity that included the ability to (1) document and code for BMI percentile and weight status diagnosis, (2) document and code for nutrition and physical activity counseling, (3) place referrals to the on-site Healthy Weight Clinics for weight management support, and (4) place orders for obesity-related laboratory studies, if appropriate.

Healthy Weight Clinics

At each intervention FQHC, we worked to develop a multidisciplinary Healthy Weight Clinic (15). The Healthy Weight Clinics were staffed by a physician, a nutritionist, and a CHW who met with each patient and family in tandem during a single, in-person, 90-minute clinical encounter. Primary care providers referred eligible patients ($BMI \geq 85$ th percentile, ages 2-18) to this specially trained, primary care team. Patients participating in the Healthy Weight Clinic engaged in dietary and physical activity assessment and goal setting and were referred to community resources to support healthy lifestyles. We aimed for patients to be followed in the Healthy Weight Clinic bimonthly for 6 months, followed by monthly for an additional 6 months, for a total of approximately 27 hours of

		Clinical Intervention Components				
		Staff Training	Decision Support Tools	Healthy Weight Clinics	Community Health Workers	Environmental Changes
Intervention Level	System	<ul style="list-style-type: none"> Advanced training on obesity prevention, assessment, and management; Medical assistant training on accurate height and weight measurements 	<ul style="list-style-type: none"> Computerized decision support tools in the EHR delivered to primary care providers to increase BMI screening and counseling; EHR-based alerts to flag children with a BMI \geq 85th percentile; Structured clinical note to guide evidence-based obesity care 	<ul style="list-style-type: none"> Healthy Weight Clinics for co-located obesity management; Multi-disciplinary weight management team, coordinated support and interactive coaching 	<ul style="list-style-type: none"> Member of the Healthy Weight Clinic team; Participant in clinical quality improvement efforts; Liaison to local health and wellness coalition activities in broader community 	<ul style="list-style-type: none"> Physician champion & community health worker support practice changes; Posters to assess readiness to change and promote behavioral goals; Promote the use of point-of-decision signage
	Individual & Family	<ul style="list-style-type: none"> Parent self-assessments of child's behavior risk factors 	<ul style="list-style-type: none"> Improved quality of care for weight management; Referral to on-site Healthy Weight Clinics for weight management support 	<ul style="list-style-type: none"> Dietary and physical activity assessment; Goal setting; Referrals to community resources 	<ul style="list-style-type: none"> "Wellness Navigator" connecting families to community resources 	<ul style="list-style-type: none"> Consistent messages on targeted behaviors through health center signage

Figure 1 Clinical intervention components in the MA-CORD study.

contacts during the 1-year period. Clinicians used the *Next Steps* guide from the National Institute for Children’s Health Care Quality to guide their counseling at each follow-up visit (19).

Community health workers

Each intervention FQHC employed a full-time CHW as a member of the primary care and multidisciplinary obesity management teams (5). The purpose of the CHWs was to (1) serve as a member of the Healthy Weight Clinic, counseling patients referred to the program; (2) participate in the FQHC’s quality improvement efforts; (3) serve as “Wellness Navigators,” connecting children and families with community resources for behavior change; and (4) act as a liaison to local health and wellness coalition activities in the broader community. They also cataloged local community resources to refer patients to and conducted parent education and training sessions on the MA-CORD target behaviors. The five target behaviors of MA-CORD were (1) replacement of water for sugary drinks; (2) \leq 2 hours of screen time per day; (3) \geq 1 hour of physical activity per day; (4) replacement of sugary, salty, fried, and fast food with fruits and vegetables; and (5) \geq 11 hours of sleep per day for 2- to 5-year-olds and \geq 10 hours for 6- to 12-year-olds.

Environmental changes

To improve the healthfulness of the clinical environment, we worked with health center administrators and the CHWs to implement clinical environmental changes. Changes were intended to support lifestyle modifications and the health of patients, visitors, and staff. Following a physical space environmental assessment completed by research staff and health center staff, we developed a

menu of options in which the center could improve. These included signage related to targeted behavior changes and promotion of water, access to healthy food options within the building, and walking challenges.

TAU site

TAU participants at the comparison FQHC received the current standard of care offered by their pediatric office. No new decision support tools, trainings, Healthy Weight Clinics, or patient educational materials for obesity were made available at the TAU site during the intervention period. All new patient educational materials were made available free of charge to the comparison community at study completion.

Outcome measurements

The primary outcome of the trial was change in age- and sex-specific BMI *z* score throughout the 2-year intervention period obtained from well-child care visits taken from children’s electronic health records. Medical assistants at each health center measured height and weight according to the written standardized protocol of the health centers and entered the information into the electronic health record. BMI and age- and sex-specific BMI *z* score were calculated at each clinical visit. We culled longitudinal data from the electronic health records of all three health centers for 6,624 children, ages 2 to 12 years, who received care at any of the three health centers between October 2010 (approximately 2 years prior to the start of the intervention) and August 2015 (approximately 20 months after the start of the intervention and the date of our final electronic health record data pull). To be included in the analyses,

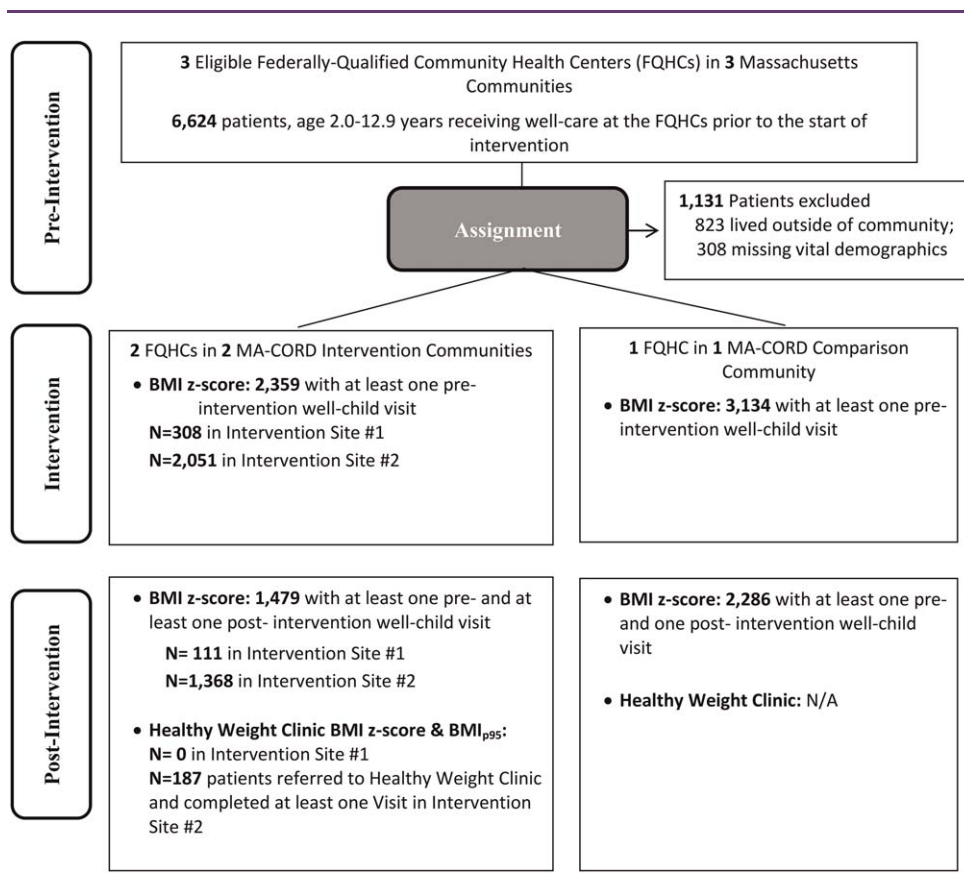


Figure 2 Participant flow for the MA-CORD clinical quasi-experimental trial.

children needed to reside in the community, have vital demographic information available (e.g., age, sex, race/ethnicity), and have at least two visits in which height and weight were measured. These included at least one visit prior to intervention start in the fall of 2013 and at least one visit after intervention start. The sample size for our longitudinal analyses included these 3,765 children with 14,452 weight and height measures (Figure 2).

The secondary outcomes of the study were changes in BMI z score and percent of BMI_{p95} (20-23) among children referred and seen for at least two visits in the Healthy Weight Clinic. We refer to a BMI that is expressed as a percentage of the 95th percentile as BMI_{p95}; values can range from < 50 (for very thin children) to > 220 (for very heavy children), and a child with a BMI equal to the 95th percentile would have a BMI_{p95} of 100% (20).

Other measures

From the electronic health record we also extracted information on clinical visit dates, child's date of birth, sex, and race/ethnicity. To assess families' exposure to the MA-CORD interventions outside of the clinical setting, we conducted a survey at baseline of parents with children ages 2.0 to 12.9 years of age who received their well-child care at Intervention Sites #1 and #2. The surveys were available in English, Spanish, and Portuguese and were administered by trained research assistants during well-child visits or by telephone

immediately following the visits. The survey assessed whether the family had a child who was enrolled in WIC, the local public elementary or middle school, and an after-school program in the community.

Statistical analysis

We used a quasi-experimental design with a TAU group and assessed longitudinal changes in BMI z score of individual children at each of the FQHCs in the two intervention communities compared to children at the TAU site. To assess BMI z score, we used linear mixed-effects regression models to account for clustering of observations over time within individuals and within the community. The model for BMI z score included indicator variables for time, intervention arm (Intervention Site #1, Intervention Site #2, or TAU), child age, child race/ethnicity, and child sex, as well as a time-after variable indicating a change after the intervention begins, with interactions for each intervention arm. These interaction terms test for changes in BMI z scores after the intervention starts at the intervention sites compared to the TAU site. We present minimally unadjusted (child age and sex only) and fully adjusted (child age, sex, and race/ethnicity) multiple regression estimates.

The Healthy Weight Clinic study used a quasi-experimental design, in which each child served as his or her own control, and measured BMI changes over time. The Healthy Weight Clinic analyses did not have a control site because these multidisciplinary clinics were not

TABLE 1 Baseline characteristics of children receiving care at the MA-CORD federally qualified community health centers, by intervention assignment

	Intervention Site #1, <i>n</i> = 111	Intervention Site #2, <i>n</i> = 1,368	TAU site, <i>n</i> = 2,286	<i>P</i> value
	Mean (SD) or <i>n</i> (%)			
Age at baseline, y	6.5 (2.9)	5.8 (3.0)	6.0 (3.0)	0.03
Male, <i>n</i> (%)	55 (49.5)	689 (50.4)	1203 (52.6)	0.37
Race/ethnicity, <i>n</i> (%)				<0.0001
White, non-Hispanic	15 (13.5)	240 (17.5)	441 (19.3)	
Hispanic/Latino	84 (75.7)	892 (65.2)	1100 (48.1)	
Black, non-Hispanic	6 (5.4)	221 (16.5)	236 (10.3)	
Asian	6 (5.4)	8 (0.6)	507 (22.2)	
Other, non-Hispanic	0 (0)	7 (0.5)	2 (0.1)	
BMI <i>z</i> score	0.81 (1.2)	0.83 (1.1)	0.86 (1.1)	0.73
BMI percentile				0.29
<85th percentile	71 (64.0)	781 (57.0)	1270 (55.5)	
≥85th to <95th percentile	12 (10.8)	252 (18.5)	450 (19.7)	
≥95th percentile	28 (25.2)	335 (24.5)	566 (24.8)	

TAU, treatment as usual.

implemented at the TAU site. To assess BMI *z* score and BMI_{p95}, we used linear mixed-effects models to account for clustering of visits by child. Models were adjusted for child age, sex, and race/ethnicity. All analyses were performed using SAS, version 9.3 (Cary, North Carolina) using PROC MIXED.

Results

Figure 2 shows the participant flow of the study. The sample size for our main analyses and outcomes included 3,765 children with 14,452 weight and height measures. Table 1 shows baseline characteristics of the study sample across the three FQHCs. Compared to children in the TAU site, both intervention sites had a higher percentage of Hispanic children, and children in Intervention Site #1 were slightly older.

Program implementation

Throughout the study period, Intervention Site #1 faced several institutional challenges that prevented full implementation of the intervention and led to substantially fewer children receiving primary care at the FQHC (24). Over the 2-year intervention period, the FQHC in Intervention Site #1 experienced a high level of attrition in senior leadership and clinical providers, relocated its facility, and ended its accredited family medicine residency program. These challenges prevented the FQHC from attracting and retaining pediatric patients and prevented the full implementation of the Healthy Weight Clinic in the practice. Thus, our evaluation of the Healthy Weight Clinic only included children in Intervention Site #2.

Overlap with MA-CORD multisector interventions

From July 2012 through April 2013, we sampled 92 parents of children in Intervention Site #1 and 240 parents in Intervention Site #2

to assess potential overlap with the MA-CORD activities in WIC, schools, and after-school programs. In Intervention Site #1, 15 out of 22 (68%) families with children aged 2 to <5 years reported receiving WIC benefits. Among parents with school-aged (≥6 years) children in Intervention Site #1, 60 out of 62 (97%) reported their child was enrolled in the community’s public school and 10 out of 62 (16%) reported their child attended an after-school program. In Intervention Site #2, 80 out of 103 (78%) families with children aged 2 to <5 years reported receiving WIC benefits. Among parents with school-aged children (≥6 years) in Intervention Site #2, 108 out of 114 (95%) reported that their child was enrolled in the community’s public school and 7 out of 114 (6%) reported their child attended an after-school program.

Main outcomes

Prior to the start of the intervention, the mean (SD) BMI *z* score of children was 0.81 (1.2) in Intervention Site #1, 0.83 (1.1) in Intervention Site #2, and 0.86 (1.1) in the TAU site. In models adjusted for child age and sex, we found that compared to children in the TAU site, children in Intervention Site #2 had lower BMI *z* scores after the intervention start (−0.16 units/y; 95% confidence interval [CI]: −0.21 to −0.12) (Table 2). Further adjustments for child race/ethnicity did not change the estimates. Compared to children in the TAU site, children in Intervention Site #1 did not have a significant difference in their BMI *z* scores over time (−0.02 units/y; 95% CI: −0.16 to 0.12).

Healthy Weight Clinic outcomes

Approximately 187 children ages 2.0 to 12.9 years were referred to the Healthy Weight Clinic in Intervention Site #2 and completed a mean (SD) of 2.56 (1.9) visits with the multidisciplinary team (Table 3). At the time of referral, the mean (SD) age of children was 7.9 (3.0) years, the mean (SD) BMI *z* score was 2.01 (0.63),

TABLE 2 Changes in BMI z score from preintervention to postintervention implementation, by intervention assignment (N = 3,765 patients; 14,452 visits)

Main outcome	Unadjusted change in BMI z score/year after intervention start, β (95% CI) ^a	P value*	Adjusted change in BMI z score/year after intervention start ^b , β (95% CI)	P value*
BMI z score (units)				
Intervention Site #2	-0.16 (-0.21 to -0.12)	<0.0001	-0.16 (-0.21 to -0.12)	<0.0001
Compared to TAU site	Reference		Reference	

^aGeneralized linear mixed-effects models with all models corrected for clustering by community and correlation within individuals.

^bAdjusted for child age, sex, and race/ethnicity.

*Type 3 overall P value evaluates equality of effects across interventions as obtained from the time × arm interaction term.

CI, confidence interval; TAU, treatment as usual.

and mean (SD) BMI_{p95} was 111.2% (17.6). In minimally and fully adjusted models, we observed a decrease in BMI z score among children in the Healthy Weight Clinic. In models adjusted for child age, sex, and race/ethnicity, BMI z score decreased by -0.07 units (95% CI: -0.10 to -0.03; P < 0.001) over the course of children’s visits to the clinic (Table 4). Similarly, in models adjusted for child age, sex, and race/ethnicity, we observed a nonsignificant decrease of 0.87% (95% CI: -1.82 to 0.09; P = 0.07) in BMI_{p95} over the course of the visits to the clinic.

Discussion

In this multilevel intervention to prevent and manage childhood obesity at Massachusetts FQHCs, we observed a modest improvement in BMI z scores at one of two intervention communities versus a TAU site. The magnitude of improvement in BMI z score was -0.16 units per year and the effects were robust to adjustment for child age, sex, and race/ethnicity. In this same intervention site, we implemented a Healthy Weight Clinic to manage children with BMI ≥ 85th percentile and found that BMI z score decreased by 0.07 units over the course of children’s visits to the clinic. We did not observe differences in BMI z score among children in the other intervention site versus the TAU site, but substantial institutional challenges led to fewer children being seen for primary care during the intervention period, and other barriers prevented the site from fully adhering to the intervention protocol. Despite the challenges to implementation, our findings lend support to a growing body of evidence that improving the quality of obesity-related care in community-based settings that see a large percentage of low-income children could lead to improvements in BMI for all children and reduction in BMI among those with overweight and obesity.

Our findings also extend the existing literature by showing that the components we implemented at the intervention FQHCs may be feasible and effective in low-resource settings. For example, Expert Committee guidelines and systematic reviews recommend universal childhood obesity screening, provision of specific nutrition and physical activity counseling, and encouraging structured weight management strategies in pediatric primary care (25,26). We implemented universal screening of BMI in the two intervention primary

care settings and developed educational materials to assist with nutrition and physical activity counseling. Second, clinical decision support tools delivered to clinicians at the point-of-care that flag children with overweight or obesity and provide a standardized note template specific for obesity management have been shown to increase the quality of obesity-related care and improve BMI outcomes (27,28). In the MA-CORD intervention FQHCs, we worked to optimize the electronic health records to plot BMI on appropriate growth charts, flag children with overweight and obesity, and provide structured, obesity-specific note templates to guide primary care management. Third, evidence suggests that multidisciplinary Healthy Weight Clinics that reorganize care to provide access to a trained team consisting of a pediatric provider, nutritionist, and case

TABLE 3 Sociodemographic characteristics of 187 children seen in the Healthy Weight Clinic between November 1, 2012, and June 30, 2014

	Healthy weight clinic patients (n = 187 patients/1,288 visits)
Age, mean (SD), y	7.9 (3.0)
Age, 2 to 5 y, n (%)	36 (19.3%)
Boy, n (%)	94 (48.1%)
Race/ethnicity, n (%)	
White, non-Hispanic	21 (11.2%)
Black, non-Hispanic	21 (11.2%)
Hispanic/Latino	145 (77.5%)
MassHealth/Medicaid, n (%)	61 (32.6%)
BMI (kg/m ²) at referral, mean (SD)	23.2 (4.8)
BMI z score at referral, mean (SD)	2.01 (0.63)
BMI _{p95} at referral, mean (SD)	111.2 (17.6)
Number of healthy weight clinic visits, mean (SD)	2.56 (1.9)
Time after referral at the last visit in days, mean (SD)	102.63 (115.8)

TABLE 4 Change in BMI z score and BMI_{p95} for 187 children referred to the Healthy Weight Clinic in Intervention Site #2 between November 1, 2012, and June 30, 2014

	Unadjusted change in BMI z score/year after intervention start, β (95% CI)	P value	Adjusted change in BMI z score/year after intervention start ^a , β (95% CI)	P value
BMI z score	-0.10 (-0.13 to -0.10)	<0.001	-0.07 (-0.10 to -0.03)	<0.001
BMI _{p95}	-0.18 (-0.68 to 0.32)	0.48	-0.87 (-1.82 to 0.09)	0.07

^aAdjusted for child age, sex, and race/ethnicity. CI, confidence interval.

manager during dedicated weight management visits are effective (15,29). Two recent studies showed that Healthy Weight Clinics improved obesity care and BMI outcomes among low-income children in Massachusetts (15,29). Our findings show that the Healthy Weight Clinic model did improve obesity care by promoting local specialization and increasing capacity for specialized care and improved child BMI outcomes.

While our study had many strengths, including the systematic, multilevel approach to clinical obesity management, the study also had limitations, and we faced several challenges. First, given the nature of the multilevel, multisector community intervention, we were not able to use a randomized or blinded design. While a randomized controlled trial provides the highest level of internal validity, in many settings—particularly low-resource settings serving vulnerable populations—randomization to a control group is not acceptable as it conflicts with the organization’s objective to serve vulnerable families (30). As a viable alternative, we used a longitudinal, quasi-experimental design with a TAU group and collected outcome data from groups before and after the study implementation. Second, the MA-CORD clinical intervention activities were embedded within other MA-CORD interventions in WIC, public schools, and after-school programs (31,32). Our process measures indicated that a large majority of eligible families were enrolled in WIC and school-age children were enrolled in the local public schools. A much lower percentage of children interacted with the after-school programs. Thus, it is possible that our intervention effects could be partially attributed to activities in the WIC and public school settings. Third, we selected a representative comparison community, and it is possible that other wellness interventions were undertaken by that community during the study period. To our knowledge, there were no systematic childhood obesity interventions implemented in the comparison community during the study period. Finally, our study faced substantial implementation challenges as previously described, and several of the barriers we encountered likely reflect the socioeconomic instability of the communities we were working in, the timing of this intervention, which began during a financial recession, and leadership turmoil in the health centers as they worked to implement the intervention. Despite these limitations, we believe our study reflects best practice in the design and evaluation of a multilevel intervention, and our results could add to the knowledge base in addressing childhood obesity in low-income communities.

In conclusion, the clinical interventions delivered through MA-CORD were associated with significant improvement in BMI z scores in one of two intervention communities. Our findings suggest

that multilevel interventions to improve childhood obesity prevention and management in low-income, primary care settings could have beneficial effects on BMI and reach the very segments of the US population who need it most. **O**

Acknowledgments

We thank the families, institutions, faculty, research staff, and students who participated in the MA-CORD study.

© 2017 The Obesity Society

References

- Ogden CL, Carroll MD, Lawman HG, et al. Trends in obesity prevalence among children and adolescents in the United States, 1988-1994 Through 2013-2014. *JAMA* 2016;315:2292-2299.
- Singh GK, Siahpush M, Kogan MD. Neighborhood socioeconomic conditions, built environments, and childhood obesity. *Health Aff (Millwood)* 2010;29:503-512.
- Singh GK, Siahpush M, Kogan MD. Rising social inequalities in US childhood obesity, 2003-2007. *Ann Epidemiol* 2010;20:40-52.
- Dooyema CA, Belay B, Foltz JL, et al. The Childhood Obesity Research Demonstration project: a comprehensive community approach to reduce childhood obesity. *Child Obes* 2013;9:454-459.
- Taveras EM, Blaine RE, Davison KK, et al. Design of the Massachusetts Childhood Obesity Research Demonstration (MA-CORD) study. *Child Obes* 2015; 11:11-22.
- Davison KK, Falbe J, Taveras EM, et al. Evaluation overview for the Massachusetts Childhood Obesity Research Demonstration (MA-CORD) project. *Child Obes* 2015;11: 23-36.
- Henke RM, Johann J, Senathirajah M, et al. Implementation of the patient-centered medical home model in facilities providing comprehensive care to medically underserved populations. *J Health Care Poor Underserved* 2016;27:1638-1646.
- Ayash CR, Simon SR, Marshall R, et al. Evaluating the impact of point-of-care decision support tools in improving diagnosis of obese children in primary care. *Obesity (Silver Spring)* 2013;21:576-582.
- Taveras EM, Marshall R, Horan CM, et al. Improving children’s obesity-related health care quality: process outcomes of a cluster-randomized controlled trial. *Obesity (Silver Spring)* 2014;22:27-31.
- Dietz WH, Solomon LS, Pronk NP, et al. An integrated framework for the prevention and treatment of obesity and its related chronic diseases. *Health Aff (Millwood)* 2015;34:1456-1463.
- Viswanathan M, Kraschnewski J, Nishikawa B, et al. Outcomes of community health worker interventions. *Evidence Report/Technology Assessment*, no. 181. Rockville, MD: Agency for Healthcare Research and Quality; 2009.
- Viswanathan M, Kraschnewski JL, Nishikawa B, et al. Outcomes and costs of community health worker interventions: a systematic review. *Med Care* 2010;48: 792-808.
- National Center for Chronic Disease Prevention and Health Promotion. *Addressing Chronic Disease Through Community Health Workers: A Policy and Systems-Level Approach*. A Policy Brief on Community Health Workers In: *Addressing Chronic Disease Through Community Health Workers: A Policy and Systems-Level Approach*. 2nd ed. Atlanta, GA: Centers for Disease Control and Prevention; 2015.

14. Taveras EM, Marshall R, Horan CM, et al. Rationale and design of the STAR randomized controlled trial to accelerate adoption of childhood obesity comparative effectiveness research. *Contemp Clin Trials* 2013;34:101-108.
15. Anand SG, Adams WG, Zuckerman BS. Specialized care of overweight children in community health centers. *Health Aff (Millwood)* 2010;29:712-717.
16. Huh SY, Rifas-Shiman SL, Taveras EM, et al. Timing of solid food introduction and risk of obesity in preschool-aged children. *Pediatrics* 2011;127:e544-e51. doi:10.1542/peds.2010-0740
17. Langley GL, Nolan KM, Nolan TW, et al. *The Improvement Guide: A Practical Approach to Enhancing Organizational Performance*. San Francisco, CA: Jossey-Bass Publishers; 2009.
18. McPherson ME, Mirkin R, Heatherley PN, et al. Educating health care professionals in advocacy for childhood obesity prevention in their communities: integrating public health and primary care in the Be Our Voice project. *Am J Public Health* 2012;102:e37-e43. doi:10.2105/AJPH.2012.300833
19. National Initiative for Children's Health Care Quality. *Next Steps: A Practitioner's Guide for Themed Follow-up Visits for Their Patients to Achieve a Healthy Weight*. Washington, DC: American Academy of Pediatrics; 2013.
20. Flegal KM, Wei R, Ogden CL, et al. Characterizing extreme values of body mass index-for-age by using the 2000 Centers for Disease Control and Prevention growth charts. *Am J Clin Nutr* 2009;90:1314-1320.
21. Fox CK, Kaizer AM, Rudser KD, et al. Meal replacements followed by topiramate for the treatment of adolescent severe obesity: a pilot randomized controlled trial. *Obesity (Silver Spring)* 2016;24:2553-2561.
22. Garnett SP, Gow M, Ho M, et al. Improved insulin sensitivity and body composition, irrespective of macronutrient intake, after a 12 month intervention in adolescents with pre-diabetes; RESIST a randomised control trial. *BMC Pediatr* 2014;14:289. doi:10.1186/s12887-014-0289-0
23. Ho M, Gow M, Halim J, et al. Effect of a prescriptive dietary intervention on psychological dimensions of eating behavior in obese adolescents. *Int J Behav Nutr Phys Act* 2013;10:119. doi:10.1186/1479-5868-10-119
24. Ganter C, Aftosmes-Tobio A, Chuang E, et al. Lessons learned by community stakeholders in the Massachusetts Childhood Obesity Research Demonstration (MA-CORD) project, 2013-2014. *Prev Chronic Dis* 2017;14:E08. doi:10.5888/pcd14.160273
25. US Preventive Services Task Force, Barton M. Screening for obesity in children and adolescents: US Preventive Services Task Force recommendation statement. *Pediatrics* 2010;125:361-367.
26. Oude Luttikhuis H, Baur L, Jansen H, et al. Interventions for treating obesity in children. *Cochrane Database Syst Rev* 2009;CD001872. doi:10.1002/14651858.CD001872.pub2
27. Taveras EM, Marshall R, Horan CM, et al. Improving children's obesity-related health care quality: process outcomes of a cluster-randomized controlled trial. *Obesity (Silver Spring)* 2014;22:27-31.
28. Taveras EM, Marshall R, Kleinman KP, et al. Comparative effectiveness of childhood obesity interventions in pediatric primary care: a cluster-randomized clinical trial. *JAMA Pediatr* 2015;169:535-542.
29. Cheng JK, Wen X, Coletti KD, et al. 2-Year BMI changes of children referred for multidisciplinary weight management. *Int J Pediatr* 2014;2014:152586. doi:10.1155/2014/152586
30. Glasgow RE, Magid DJ, Beck A, et al. Practical clinical trials for translating research to practice: design and measurement recommendations. *Med Care* 2005;43:551-557.
31. Woo Baidal JA, Nelson CC, Perkins ME, et al. Childhood obesity prevention in the Women, Infants, and Children Program: Outcomes of the MA-CORD study. *Obesity (Silver Spring)* 2017;25:1167-1174.
32. Franckle RL, Falbe J, Gortmaker S, et al. Student obesity prevalence and behavioral outcomes for the Massachusetts Childhood Obesity Research Demonstration project. *Obesity (Silver Spring)* 2017;25:1175-1182.