Addressing childhood obesity in low income, ethnically diverse families: outcomes and peer effects of MEND 7–13 when delivered at scale in US communities

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Abstract

Objectives: Implementation of a large-scale, child weight management program in low-income, ethnically diverse communities provided an important opportunity to evaluate its effectiveness under service level conditions (i.e. provision as a primary care child weight management service).

Methods: MEND 7–13 is a community-based, multicomponent, childhood obesity intervention designed to improve dietary, physical activity and sedentary behaviors. It comprises twice weekly sessions for 10 consecutive weeks (35 contact hours) and is delivered to groups of children and accompanying parents/caregivers. The evaluation used an uncontrolled, repeated measures design. 3,782 children with overweight or obesity attended 415 MEND 7–13 programs in eight US states. 2,482 children (65.6%) had complete data for change in zBMI. The intervention targeted low-income, ethnically diverse families. Changes in anthropometric, cardiovascular fitness and psychological outcomes were evaluated. A longitudinal multivariate imputation model was used to impute missing data. Peer effects analysis was conducted using the instrumental variables approach and group fixed effects.

Results: Mean changes in BMI and zBMI at 10 weeks were -0.49 kg/m^2 (95%CI: -0.67, -0.31) and -0.06 (95%CI: -0.08, -0.05) respectively. Benefits were observed for cardiovascular fitness and psychological outcomes. Mean peer reduction in zBMI was associated with a reduction in participant zBMI in the instrumental variables model (B=0.78, p=0.04, 95%CI: 0.03, 1.53). Mean program attendance and retention were 73.9% and 88.5% respectively.

Conclusion: Implementing MEND 7–13 under service level conditions was associated with short-term improvements in anthropometric, fitness and psychological indices in a large sample of low-income, ethnically diverse children with overweight and obesity. A

peer effect was quantified showing that benefits for an individual child were enhanced, if peers in the same group also performed well. To our knowledge, this is the first US study to evaluate outcomes of an up-scaled community-based, child weight management program and to show positive peer effects associated with participation in the intervention.

Introduction

Childhood obesity is a major public health issue with significant economic costs, and is particularly prevalent among low-income, ethnically diverse populations.[1] The widening health disparities with regard to children's adiposity- such as the higher obesity rates in African American and Hispanic children- are particularly evident in the US and necessitate the development of interventions which are effective in low-income, ethnically diverse populations.[2]

Upscaling community interventions, i.e. making them available to the wider population, is essential to address existing obesity rates. Nevertheless, evaluations of up-scaled interventions have highlighted that the impact under conditions of normal service delivery can vary from that observed under trial conditions.[3-5] Whilst such differences may be inevitable, it is important to delineate the ways in which up-scaled interventions may differ in reach and impact, to take steps to reduce inequities in service provision.

Up-scaled interventions are usually delivered to groups in order to be more cost-effective and achieve public health outcomes.[6] Within groups, peer effects may play an important role in intervention effectiveness. It has been suggested that higher BMIs can be 'contagious' and that obesity may be spreading from one person to another via social ties, although the underlying mechanisms for this clustering have not yet been

identified.[7-9] To our knowledge, there is currently no research on peer effects in group weight management interventions, i.e. investigating if peer positive outcomes (e.g. reduction in BMI or improvement of other outcomes) can lead to positive outcomes for the whole group. Exploring this dimension is important, as successful childhood obesity interventions offered to groups may have additional benefits for participating children.

MEND 7–13 is a group-based childhood weight management program, originally developed in 2001 in the UK. Following establishment of feasibility and efficacy[10, 11] it was up-scaled extensively as a national childhood weight management program in the UK, with service level evaluation (i.e. not for research, but following the provision of MEND 7–13 as a primary care child weight management service) confirming efficacy trial outcomes, both in the short and long term.[12, 13] MEND 7–13 was then culturally adapted, piloted and scaled-up in other countries (US, Canada, Australia and the Netherlands).

In the US, MEND 7–13 was evaluated as part of the CDC Texas Childhood Obesity Demonstration (TX CORD) project (called 'MEND/CATCH6-12' for the study purpose), which was designed to address childhood obesity by targeting low-income, ethnically diverse children with obesity. For ages 6-8, MEND/CATCH6-12 was more efficacious in $\%BMI_{p95}$ reduction at 3 months [effect size (95% CI): -1.94 (-3.88, -0.01)], but not 12 months compared to controls. Despite efforts to engage families, attendance was low (approximately 50%) during the initial 3-month intensive phase which included the MEND/CATCH6-12. The intensive phase was followed by the 9-month transition phase, in which reinforcement sessions were offered monthly and YMCA sports were offered twice weekly.[14]

Following these results, the current study evaluated the impact of implementing MEND 7–13 under service level conditions, in a large sample of low-income, ethnically diverse families in the US and also investigated potential peer effects.

Methods

Study design

The study employed an uncontrolled repeated measures design. Changes in outcomes were evaluated following implementation of MEND 7–13 when delivered in community settings under service level conditions.

Between October 2008 and December 2014, participants from CA, CO, IL, MO, NC, NY, TX, VA and Washington DC took part in MEND 7–13, where funding organizations (see below) paid for programs to be offered free to families by community-based organizations. Recruitment was undertaken by local program managers using a variety of techniques (e.g. health professional referral, print media, social media, websites, word of mouth). Children were eligible if they had overweight or obesity,[15] were aged 7 to 13 years, and had no serious parental or physician reported clinical conditions, co-morbidities, physical disabilities or learning difficulties. Parent/caregiver attendance was mandatory at all program sessions. Written consent by a parent/caregiver was a requirement for participation.

Study intervention

MEND 7–13 is a multi-component, family-based intervention designed to improve diet and physical activity through education, behavior change, skills training, and

138 motivational enhancement.[3] It is delivered twice a week for 10 consecutive weeks (a
139 total of 20 sessions and 35 contact hours) to groups of up to 15 children and their
140 accompanying parents/caregivers. MEND 7–13 is delivered in community settings (e.g.
141 schools, recreation, community and faith-based venues) by trained professionals
142 (predominantly of recreation, physical activity and nutrition background) and by a
143 variety of partner organizations.

144 Program fidelity is supported by manualization of the program's content, standardized
145 training of all staff (see below), common resources, standardized measurement
146 procedures, online data entry, automated family feedback, quality assurance program
147 visits and continuous feedback from trainers and families, leading to continuous program
148 development and improvement.[11]

149 Training for MEND deliverers consists of three modules. The first is a distance learning
150 module including theory content on each of the MEND components (behavior change,
151 nutrition, physical activity) and on program structure. A self-assessment is included for
152 deliverers to check their learning before attending module two. The second module is a
153 two-day in person workshop that coaches participants to deliver the MEND sessions and
154 facilitate groups effectively. A comprehensive assessment is completed two to four
155 weeks after the workshop. The final module is a reflective-practice log completed by
156 deliverers during their first program delivery.

157 MEND 7–13 has been culturally adapted and localized to cater for families' ethnic and
158 social backgrounds and where necessary, program delivery and resources are provided in
159 Spanish. A health economic evaluation of MEND 7–13 in the UK found it to be a cost-
160 effective intervention for payors to reduce the number of children with overweight and
161 obesity. It was also found to provide returns of 967%-1331% on public investment.[16] To

date, all MEND programs internationally have been delivered free to families, with costs borne by community-based organizations delivering the programs. The total cost per family for funding organizations varies according to factors including project size and complexity, number of children and type of delivery staff and venues. MEND 7–13 costs generally range between $500 and $1400 per parent and child. In kind contributions (e.g. space or time) and different delivery models can reduce this further.

Organizations pay for the programs for a variety of reasons. Examples include: 1) funder organizations may wish to pay for training to build local capacity and programming to benefit local or specific populations, 2) healthcare providers may cover the delivery costs for their patient population due to health and potential reimbursement benefits, 3) public health departments or community-based organizations may pay for MEND 7–13 to improve the health behaviors of their populations, especially low-income, ethnically diverse communities, as part of their core missions. Many other types of organizations have chosen to pay for and/or deliver the program for varying reasons. Payors value quantifying the impact of the programs, and sometimes need this information to justify funding, and therefore pay for the time and equipment to perform and analyze measurements.

MEND 7–13 is in line with the US Preventive Services Task Force recommendations for child weight management (moderate intensity comprehensive behavioral program) and the Academy of Nutrition and Dietetics position on interventions for the prevention and treatment of pediatric overweight and obesity.[17, 18]

Outcome measures

Baseline and post-program measurements were part of the MEND 7–13 curriculum. Baseline measurements were taken during the first session and post-program measurements during session 19. All measurements were taken by the local team delivering the program at each site.

Anthropometry

Body weight (kg) and height (cm) were measured using standardized procedures.[19] BMI was calculated as body weight(kg)/height(m^2). Waist circumference was measured 4 cm above the umbilicus.[20] BMI z-score (zBMI) and % overweight were calculated using Centers for Disease Control (CDC) reference data.[15] BMI as a percentage of the 95th centile (%BMI_{p95}) was also calculated, in order to address the CDC growth chart limitations for children with BMI values greater than the 95th centile.[21-23]

Cardiovascular fitness

Cardiovascular fitness was assessed by the Young Men's Christian Association (YMCA) step test.[24] This is a sub-maximal test, which requires the participant to step up and down off a step at a pre-determined height for three minutes. After three minutes, the child stops, sits down and their pulse (wrist or neck) is counted for one full minute. This test has been used in the Medical College of Georgia FitKid Project.[25, 26]

Psychological indices

The 25-item parent-rated version of the strengths and difficulties questionnaire (SDQ) was used to assess children's mental health.[27] Body esteem was assessed using

Mendelson's body esteem scale, a child-reported questionnaire that measures the way a child thinks and feels about the appearance of their body.[28] Self-esteem was assessed using the child-reported Harter Self-Perception Profile and the Rosenberg's self-esteem scale. [29, 30] Children's Quality of Life was assessed using 'Sizing them up©', an obesity-specific, parent-reported measure of health-related quality of life and Pediatric Quality of Life Inventory (PEDSQL®), a questionnaire that measures children's self-reported health-related quality of life.[31, 32] The physical and psychosocial sub-scales of PEDSQL® were included in the current analysis, as these are consistently impaired in overweight and obese children.[33] In addition, parental physical and mental health were assessed using the Short Form Health Survey (SF12®) questionnaire.[34]

Demographics

Socioeconomic information was collected based on the US Census questionnaire.[35]

Attendance and dropout

Delivery partners recorded attendance of participants at each session. Program attendance (%) was calculated as the percentage of sessions attended by each child and their accompanying parent/caregiver. Children were classified as dropouts if they attended ≤5/20 (≤25%) of program sessions. As there is no standard definition for completion for programs of this type, this cutoff was used on the basis of previous publications of the MEND intervention.[4, 36]

Peer effects

For each participant within each group, the mean zBMI at baseline of all the other participants belonging in the same group was calculated, leaving out the index child's value. This was also done for change in zBMI. Thus, the peer variables were defined as the leave-one-out means. For each child of each group an increase in zBMI was theorized to be associated with an increase in mean change in zBMI.

Data cleaning and statistical analysis

Due to the data being collected under service level conditions by non-researchers, several procedures were undertaken to ensure data quality. This included 1) standardized theoretical and practical training of all professionals who performed measurements and data entry, 2) implementing validations at the point of computerized data entry to check for implausible values and 3) removing outliers from the dataset prior to performing any statistical analysis. Height, weight and waist circumference were evaluated for outliers against CDC reference data.[15] Participants who were more than five standard deviations from the mean were examined graphically and excluded on a case by case basis. Heart rate was evaluated against age specific mean and standard deviations for children aged 0-18 as reported by Fleming et al (2011).[37] Those which were more than five standard deviations from the mean were examined. Questionnaire data were cross checked to ensure that no observations fell outside of the theoretical ranges. Figure 1 summarizes the study flow chart and Table 1 shows the % missing data at baseline and follow-up.

A longitudinal [repeat measures (n=7,564) nested in participants (n=3,782)] multivariate imputation model was used to impute missing data at baseline and follow up. Data were imputed using a set of auxiliary variables including all analysis variables for children (age, gender, ethnicity, all outcome variables, participant attendance), parents/caregivers

data (BMI, socio-demographic), and program characteristics (group size, mean group age). Missing data were assumed missing at random. Ten imputed datasets were produced. Mean changes in outcomes were calculated across all ten datasets and parameters were combined using Rubin's rules.[38] For the analysis and reporting of missing data and multiple imputation the guidelines of Sterne et al were followed.[39]

In the peer effects analysis, the correlation between a child's change in zBMI and peers in the group was investigated. This correlation has three potential sources, as documented by Manski: 1) endogenous effects (child zBMI change affected by peer zBMI change), 2) exogenous (contextual) effects (peer pre-determined characteristics affecting change in zBMI) and 3) correlated effects (common unobserved characteristic affecting both own and peer change in zBMI, such as a talented MEND deliverer with high ability).[40]

Following the literature in similar setups, we assumed that there are no expected exogenous (contextual) effects (e.g. effect of peer income or ethnicity on a child's change in zBMI),[9, 41-43] as peers are mostly likely to influence one's change in zBMI only through their change in zBMI. This assumption is more plausible in the current study, as it was unlikely that children assigned to each program knew each other and therefore also unlikely they could have been exposed to their peers' family background. Thus, any peer effect should be attributed to the change in zBMI.

Endogenous effects were investigated using the instrumental variables model. Since the peer zBMI change affects individual zBMI change, and vice-versa, a characteristic affecting individual zBMI change only through peer zBMI change was needed to act as an instrument. In accordance with the literature, parental characteristics such as parent BMI, are good candidates.[9, 44] It was therefore reasonable to assume that peer parental

BMI affected the change in an individual's zBMI only through peer change in zBMI, especially since peer baseline zBMI was controlled for. In addition, as suggested by Von Hinke, et al,[44] the instrument at the individual level (i.e. parental BMI) was also included in the main second-stage equation. Finally, instructor fixed effects were used to control for any unobserved characteristic that might have influenced the group zBMI change through deliverer's ability or venue facilities. Jackknife standard errors were reported for the fixed effects model, as they are more robust in cases of small number of clusters (as in this study). This approach ensures that standard errors are not driven by a particular instructor.

Analyses using pairwise complete case analysis were undertaken. Differences in dropout rate were investigated using independent sample t-test for continuous variables and chi squared test for categorical variables. Multiple imputation models were fitted in REALCOM, and other data analysis was performed using STATA version 14.

Results

3,782 children attended 415 MEND 7–13 program between October 2008 and December 2014, of whom 2,738 (65.6%) had complete data for change in BMI and zBMI. Mean program attendance was 73.9% and program retention rate was 88.5%. Dropout rate was higher among children from single parent households, who spoke a language other than English at home, whose parent/caregiver had lower education, as well as those with a higher SDQ score. Complete outcome data at baseline and follow-up were available to varying degrees (Table 1). Descriptive statistics were therefore estimated using multiply imputed data, with complete case data for comparison (Tables 2 and 3).

Outcome results

Mean change in outcomes calculated with imputed data showed that participation in MEND 7–13 was associated with reductions in BMI (B=-0.49kg/m^2;95%CI=-0.67,-0.31), zBMI (B=-0.06;95%CI=-0.08,-0.05), % overweight (B=-4.44;95%CI=-5.41,-3.47), $\%BMI_{95}$ (B=-3.56;95%CI=-4.19,-2.92), waist circumference (B=-1.00cm,95%CI=-1.37,-0.63), recovery heart rate (B=-5.29 beats per minute,95%CI=-5.98,-4.60) and strengths and difficulties score (B=-1.60;95%CI=-1.82,-1.38). Participation was also associated with increases in self-esteem (Rosenberg: B=1.48;95%CI=1.25,1.71, Harter: B=0.13;95%CI=0.10,0.16), body esteem (B=2.21;95%CI=1.99,2.43), parent-reported quality of life (B=5.07,95%CI=4.56,5.58), child-reported quality of life (Psychosocial scale: B=4.41;95%CI=3.77,5.05, Physical scale: B=5.47; 95%CI=4.81,6.13) and parental physical and mental health (B=1.73;95%CI=1.42,2.05 and B=3.07;95%CI=2.71,3.44 respectively) (Table 3). Improvements in all study outcomes were observed in both pairwise and imputed data analysis (Table 4). Improvements were smaller in imputed data for most outcomes, with the exception of zBMI and Harter self-esteem score, which were the same in both imputed and complete case analyses and % overweight, $\%BMI_{p95}$, strengths and difficulties score, SF12® Physical score and PEDSQL® Psychosocial score which were larger in the imputed data (Table 4).

Peer effects

According to peer effect analysis, one unit decrease of peer mean change zBMI was associated with a 0.17 unit (P=0.02) decrease in child's change in zBMI (Table 5 Fixed Effects model) accounting for correlated effects (i.e. through instructor), but not for an uncontrolled confounding variable. Using the instrumental variables (IV) approach, one unit decrease of peer mean change in zBMI was associated with 0.8 units (P=0.03)

decrease in child's change in zBMI in the model not including the instrument at an individual level (Table 5, IV Fixed Effects Model 1), and 0.78 units (P=0.04) in the model including the instrument at an individual level (Table 5, IV Fixed Effects Model 2). An increase of 10% in attendance was associated with a decrease of 0.01 units (P=0.004) in a child's change in zBMI. For the IV models the F-statistics in the first stage were 33.86 and 32.11, respectively, indicating that the instrument was strongly correlated with the mean peer change zBMI. All models were controlled for individual baseline zBMI and peer baseline zBMI.

Discussion

The current study evaluated anthropometric, cardiovascular fitness and psychological outcomes following an up-scaled childhood obesity intervention, when delivered to families under service level delivery conditions. The present intervention targeted low-income, ethnically diverse families, resulting in recruitment of a population of 64.4% Hispanic, 22.3% African Americans and 56.8% with an income <$30,000 per year. Given the intensity of the intervention, MEND 7–13 achieved high levels of program attendance (73.9%) and program retention rate (88.5%), which is important as available literature shows that such interventions often suffer from high attrition rates.[46-48] Program attendance rate was higher than other up-scaled programs and higher than the TX CORD trial.[5, 14, 47] This is a significant finding, given that clinical trial retention rates are traditionally higher compared to real world implementations. As low-income, ethnically diverse populations are at increased risk of obesity and associated co-morbidities,[1] participation in culturally appropriate, weight management interventions is crucial. According to the current findings, attending MEND 7–13 was associated with short-term improvements in anthropometric, cardiovascular fitness and psychological

354 indices in a large sample of low-income, ethnically diverse overweight and obese
355 children.
356 More precisely, reductions were observed in BMI (-0.49 kg/m^2), zBMI (-0.06), %
357 overweight (-4.44), %BMI$_{95}$ (-3.56) and waist circumference (-1.00 cm). These
358 reductions are comparable with available literature on child weight management
359 interventions in high risk US populations.[49, 50] Importantly, the current study resulted in
360 greater reductions in BMI outcomes (BMI and %BMI$_{p95}$) compared to the recent TX
361 CORD trial 3-month longitudinal results for children attending MEND aged 6-12 years
362 (BMI change: -0.25/-0.29 kg/m^2 for ages 6-8 and 9-12 respectively; %BMI$_{95}$ change: -
363 2.32/-2.59 units for ages 6-8 and 9-12 respectively).[14] Larger BMI/zBMI reductions were
364 reported in the MEND UK RCT (-0.9 kg/m^2 and -0.20 respectively),[51] a population-level
365 MEND UK longitudinal evaluation of 9,563 participants (-0.7 kg/m^2 and -0.20
366 respectively)[13] and the Australian dissemination of the program in 2,812 participants (-
367 0.65 kg/m^2 and -0.11 respectively)[5]. In terms of zBMI, it should be noted that the use of
368 different growth charts in the US, which have inherent problems in the assessment of
369 children's adiposity for higher zBMI values[21-23] may at least partly justify these
370 differences. Also, differences in population characteristics and settings do not allow
371 direct study comparisons. And lastly, there are currently no agreed recommendations on
372 magnitude of zBMI change required to achieve clinical significance following child
373 weight management interventions, while benefits in several parameters have been
374 reported irrespective of zBMI change.[52, 53]
375 Participation in MEND 7–13 was associated with improved cardiovascular fitness, which
376 may be attributed to the physical activity provided during the program (CATCH or
377 SPARK MEND activity curriculum),[54, 55] as well as family encouragement to undertake
378 additional lifestyle activities. This finding is important given the high representation of

low income and minority groups, who often have lower physical activity and increased sedentary activity compared to the general population.[56] Also, regardless of weight status and social background, improved cardiovascular fitness and increased physical activity have positive effects on children's physical and psychological wellbeing.[57]

The current study also identified improvements in self-esteem and body esteem, as well as a reduction in psychological symptoms as measured by the SDQ. This is important as body dissatisfaction and poor self-esteem are often associated with obesity in children and constitute risk factors for the development of future psychological problems such as eating disorders.[58] Therefore, the observed changes towards improved self- and body esteem indicate that the intervention conferred a short term psychological benefit in factors known to increase future risk of mental health issues in this population.

Quality of life is often impaired in children with increased body weight.[33] This impairment is more pronounced among Hispanic children and those from lower socioeconomic backgrounds.[59] In the current study, improvements in the psychosocial and physical domains of the PEDSQL® were noted, as well as better parental perception of children's quality of life. The improvements in PEDSQL® physical domain indicate that the physical activity element of the intervention may have enhanced children's perceptions of their ability to perform everyday activities. Also, healthier alternatives in leisure time and sedentary activities as instructed during the intervention could have contributed to the observed improvements. Participation was also associated with an improvement in parental quality of life, as measured by the SF12®, suggesting that that the benefits of the intervention may extend to the whole family.

Community interventions need to be acceptable, easily accessible and their language and content specifically tailored to the target population. The research underpinning MEND 7–13, as well as its design and mode of delivery make the intervention suitable for such

large-scale, real-world implementation. Also, the language and cultural adaptation of MEND 7–13 makes it a valuable option for children's weight management in diverse communities.

Approximately a third of the 3,782 children with BMI data at baseline were not measured at follow-up. This loss to follow-up often systematically varies with socio-demographic groups[47] and has also been observed in studies of MEND in the UK.[13] In order to understand the full impact of the intervention for all participants, a longitudinal multiple imputation model was used to impute missing data at both time points. By comparing analyses based on multiply imputed and complete case data, the direct impact of loss to follow-up on findings could be evaluated. Results suggested that complete case estimates of change in outcomes were largely greater than those for multiply imputed data. However, the direction, general magnitude of associations, and statistical significance remained the same. This suggests that had all the participants who started, completed the intervention, improvements in outcomes would have been smaller on average, but would still reflect improved anthropometry, physical and psychological health.

Peer effects

Obesity clusters within social networks, however the underlying mechanisms fuelling this relationship remain largely unknown and controversial, especially with regards to the 'social contagion theory' suggested by Christakis et al.[7, 60] It is generally accepted that peers can affect weight via influencing food choices and activity pattern.[61, 62] Also, there is some evidence of collateral health benefits for untreated family members when an individual makes efforts to lose weight.[55, 63] However, little is known about the potential peer effects that may result from an obesity management intervention,

especially among children.[9, 64] In the current study, a peer effect was quantified showing that benefits for an individual child were higher if peers in the same group also performed well, i.e. group zBMI reduction was found to positively influence individual zBMI reduction. This may be attributed to peer modeling and impression management processes.[62] These findings provide additional evidence to support group delivery of childhood obesity interventions, especially in community settings where the social network effects can have a wider impact.[9] Another important finding was that increased attendance was associated with greater decrease in zBMI. Therefore, supporting families to attend more program sessions can maximize intervention benefits.[65] These preliminary results should be further explored in order to verify the observed effects and to understand the underlying mechanisms and identify potential ways to further improve the observed benefits.

Strengths and limitations

Strengths of the current evaluation include the large, geographically spread sample size, population sociodemographic characteristics (high proportions of low income, minority groups), high program attendance and program retention rates, variety of outcomes and implementation under conditions of service level delivery. Also, to our knowledge, this is the first study to investigate peer effects as a consequence of participating in a childhood obesity intervention. Limitations include short term duration, potential measurement bias as data collection was performed by the program deliverers who received standardized training, but were not scientific experts skilled in performing anthropometrical measurements, lack of a control group, lack of validated physical activity and dietary intake data and lack of puberty data. In addition, assessment of socioeconomic status was conducted by comparing available data against the US Census,

454 which may not be the most sophisticated assessment method. Also, due to the fact that
455 the intervention was implemented under real-world conditions there was considerable
456 data loss at follow-up, which multiple imputation analysis aimed to reduce. More
457 precisely, by multiple imputing outcome data, bias introduced by systematic differences
458 in attrition was taken into account in the estimates of changes in outcomes. Lastly,
459 program dropout rate was higher among participants from low-income, ethnically
460 diverse families, despite the high needs in these families.
461
462 **Conclusion**
463 Implementation of MEND 7–13 in a large sample of low income, minority children
464 across the US was associated with important short-term health benefits. To our
465 knowledge, this is the first report of an up-scaled, community-based, childhood obesity
466 intervention delivered to low-income, ethnically diverse families in the US and the first
467 study to show positive peer effects associated with participation in a childhood obesity
468 intervention. Given the urgent need for effective solutions to the growing problem of
469 childhood obesity, such efforts should be further evaluated, in order to investigate if the
470 observed short-term positive results can be further improved and sustained in the longer
471 term, as demonstrated in the MEND 7-13 UK RCT and UK longitudinal evaluation.[11, 12]
472 Also, given that increased program attendance seems to result in better intervention
473 outcomes, future research is needed to examine ways to increase program engagement
474 and retention, particularly in low-income, ethnically diverse families.
475
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Table 1: Missing data at baseline (demographics and outcomes) and follow-up (outcomes only)

	% of missing data at baseline	% missing data at follow-up
Demographic characteristics		
Age	0.0	-
Gender	0.0	-
Ethnicity	22.6	-
Is child of Hispanic origin?	13.8	-
Language other than English spoken at home	20.8	-
Family income	23.3	-
Parent/caregiver highest year of school	15.1	-
Single parent	12.8	-
Do you consider yourself underinsured?	21.9	-
Number of children in household	22.8	-
Outcomes		
BMI (kg/m^2)	0.0	34.4
zBMI	0.0	34.4
% overweight	0.0	34.4
$\%BMI_{p95}$	0.0	34.4
Waist circumference (cm)	2.1	35.0
Recovery heart rate (beats per minute)	2.1	32.3
Strengths and difficulties questionnaire (score 0-40)	8.0	37.7
Rosenberg self-esteem (score 0-30)	6.5	36.0
Harter self-esteem (score 1-4)	13.6	41.6
Body esteem (score 0-24)	10.6	40.4
Sizing them up© Quality of Life score (0-100)	9.3	39.2
SF12® physical score (0-100)	7.2	36.6
SF12® mental score (0-100)	7.2	36.6
Psychosocial Health (PEDSQL®) (0-100)	10.7	38.3
Physical Health (PEDSQL®) (0-100)	4.2	33.3

BMI: Body Mass Index, zBMI: BMI z-score, $\%BMI_{p95}$:BMI as a percentage of the 95^{th} centile, SF12®: Short Form Health Survey 12, PEDSQL®: Pediatric Quality of Life Inventory

Table 2: Demographic characteristics of participants and families using multiply imputed and pairwise complete case data

	Multiple imputation data		Pairwise complete case data	
Variable	**N**	**Mean/% [95% CI]**	**N**	**Mean/% [95% CI]**
Age (years)	3,782	10.08 [10.02,10.13]	3,782	10.08 [10.02,10.13]
Gender (%)	3,782		3,782	
Male		53.46 [52,55.05]		53.46 [51.87,55.05]
Female		46.54 [45,48.13]		46.54 [44.95,48.13]
Ethnicity (%)	3,782		2,927	
White		60.07 [58,61.74]		59.79 [58.00,61.55]
Non-white		18.00 [17,19.29]		17.90 [16.55,19.33]
African American		21.94 [21,23.34]		22.31 [20.84,23.85]
Is child of Hispanic origin? (%)	3,782		3,259	
Non-Hispanic		35.17 [34,36.72]		35.62 [34.00,37.29]
Hispanic		64.83 [63,66.39]		64.38 [62.71,66.00]
Language other than English spoken at home (%)	3,782		2,994	
No		0.49 [0.47,0.50]		48.06 [46.28,49.86]
Yes		0.51 [0.50,0.53]		51.94 [50.14,53.72]
Family income (%)	3,782		2,899	
$0 - 9,999		14.02 [13,15.19]		13.94 [12.72,15.25]
$10,000 - 19,999		21.72 [20,23.12]		21.63 [20.17,23.17]
$20,000 - 29,999		20.86 [20,22.21]		21.18 [19.73,22.71]
$30,000 - 39,999		12.81 [12,13.94]		12.87 [11.70,14.14]
$40,000 - 49,999		9.10 [8,10.04]		8.80 [7.82,9.88]
$50,000 - 59,999		5.80 [5,6.58]		5.93 [5.13,6.85]
$60,000 - 69,999		3.84 [3,4.47]		3.73 [3.09,4.48]
$70,000 - 79,999		2.65 [2,3.19]		2.83 [2.28,3.50]
$80,000 -89,999		2.37 [2,2.87]		2.38 [1.88,3.00]
$90,000 -99,000		1.94 [1,2.38]		1.93 [1.49,2.50]
$100,000 +		4.88 [4,5.58]		4.79 [4.07,5.64]
Parent/caregiver highest year of school (%)	3,782		3,212	
Some high school		21.21 [20,22.55]		20.98 [19.61,22.43]
HS Diploma, some college or associates degree		58.47 [57,60.06]		58.69 [56.97,60.38]
Bachelor's degree		14.01 [13,15.13]		14.13 [12.97,15.38]
Master’s degree		6.31 [6,7.10]		6.20 [5.41,7.08]
Single parent (%)	3,782		3,297	
No		67.21 [66,68.75]		67.06 [65.44,68.65]
Yes		32.79 [31,34.34]		32.94 [31.35,34.56]
Do you consider yourself underinsured? (%)	3,782		2,954	
No		69.62 [68,71.13]		69.74 [68.05,71.37]
Yes		30.38 [29,31.90]		30.26 [28.63,31.95]
Number of children in household (%)	3,782		2,919	
1		17.41 [16,18.68]		17.44 [16.10,18.86]
2		37.40 [36,39.08]		37.51 [35.77,39.29]
3		28.38 [27,29.91]		28.26 [26.66,29.93]
4		11.44 [10,12.57]		11.48 [10.37,12.69]
5 or more		5.37 [5,6.16]		5.31 [4.55,6.19]

CI: Confidence Interval

Table 3: Mean outcomes in first and last session, and change – using multiply imputed data (N =3,782)

	Before MEND 7–13	**After MEND 7–13**	**Change**
Variable	**B [95% CI]**	**B [95% CI]**	**B [95% CI]**
BMI (kg/m2)	27.71 [27.54,27.89]	27.22 [27.03,27.42]	-0.49 [-0.67,-0.31]
zBMI	2.14 [2.13,2.15]	2.08 [2.06,2.10]	-0.06 [-0.08,-0.05]
% overweight	164.14 [163.19,165.09]	159.70 [158.66,160.74]	-4.44 [-5.41,-3.47]
$\%BMI_{p95}$	120.70 [119.99,121.40]	117.14 [116.45,117.83]	-3.56 [-4.19,-2.92]
Waist circumference (cm)	86.22 [85.81,86.63]	85.22 [84.81,85.63]	-1.00 [-1.37,-0.63]
Recovery heart rate (beats per minute)	107.34 [106.68,108.00]	102.05 [101.41,102.69]	-5.29 [-5.98,-4.60]
Strengths and difficulties questionnaire (score 0-40)	10.68 [10.48,10.87]	9.08 [8.88,9.27]	-1.60 [-1.82,-1.38]
Rosenberg self-esteem (score 0-30)	20.39 [20.19,20.59]	21.87 [21.65,22.09]	1.48 [1.25,1.71]
Harter self-esteem (score 1-4)	2.85 [2.83,2.87]	2.98 [2.95,3.00]	0.13 [0.10,0.16]
Body esteem (score 0-24)	12.04 [11.85,12.23]	14.25 [14.04,14.46]	2.21 [1.99,2.43]
Sizing them up© Quality of Life score (0-100)	76.40 [75.92,76.89]	81.47 [81.03,81.91]	5.07 [4.56,5.58]
SF12® physical score (0-100)	47.83 [47.55,48.10]	49.56 [49.29,49.83]	1.73 [1.42,2.05]
SF12® mental score (0-100)	48.90 [48.59,49.21]	51.97 [51.69,52.26]	3.07 [2.71,3.44]
Psychosocial Health (PEDSQL®) (0-100)	73.16 [72.61,73.71]	77.57 [77.00,78.14]	4.41 [3.77,5.05]
Physical Health (PEDSQL®) (0-100)	75.99 [75.41,76.57]	81.46 [80.92,81.99]	5.47 [4.81,6.13]

CI: Confidence Interval, BMI: Body Mass Index, zBMI: BMI z-score, $\%BMI_{p95}$: BMI as a percentage of the 95^{th} centile, SF12®: Short Form Health Survey 12, PEDSQL®: Pediatric Quality of Life Inventory

Table 4: Mean change in outcomes - comparison of imputed (N=3,782) and pairwise complete case data (N varies)

	Change - imputed data		**Change – pairwise complete case**	
Variable	**N**	**B [95% CI]**	**N**	**B [95% CI]**
BMI (kg/m2)	3,782	-0.49 [-0.67,-0.31]	2,482	-0.50 [-0.53,-0.46]
zBMI	3,782	-0.06 [-0.08,-0.05]	2,482	-0.06 [-0.06,-0.05]
% overweight	3,782	-4.44 [-5.41,-3.47]	2,482	-3.81 [-4.03,-3.60]
$\%BMI_{p95}$	3,782	-3.56 [-4.19,-2.92]	2,482	-3.13 [-3.29,-2.97]
Waist circumference (cm)	3,782	-1.00 [-1.37,-0.63]	2,458	-1.06 [-1.20,-0.91]
Recovery heart rate (beats per minute)	3,782	-5.29 [-5.98,-4.60]	2,560	-5.60 [-6.27,-4.93]
Strengths and difficulties questionnaire (score 0-40)	3,782	-1.60 [-1.82,-1.38]	2,358	-1.51 [-1.70,-1.31]
Rosenberg self-esteem (score 0-30)	3,782	1.48 [1.25,1.71]	2,419	1.60 [1.37,1.82]
Harter self-esteem (score 1-4)	3,782	0.13 [0.10,0.16]	2,207	0.13 [0.10,0.16]
Body esteem (score 0-24)	3,782	2.21 [1.99,2.43]	2,253	2.37 [2.17,2.57]
Sizing them up© QoL score (0-100)	3,782	5.07 [4.56,5.58]	2,300	5.20 [4.73,5.68]
SF12® physical score (0-100)	3,782	1.73 [1.42,2.05]	2,399	1.69 [1.37,2.01]
SF12® mental score (0-100)	3,782	3.07 [2.71,3.44]	2,399	3.17 [2.79,3.55]
Psychosocial Health (PEDSQL®) (0-100)	3,782	4.41 [3.77,5.05]	2,333	4.29 [3.70,4.89]
Physical Health (PEDSQL®) (0-100)	3,782	5.47 [4.81,6.13]	2,522	5.55 [4.90,6.21]

CI: Confidence Interval, BMI: Body Mass Index, zBMI: BMI z-score, $\%BMI_{p95}$: BMI as a percentage of the 95^{th} centile, SF12®: Short Form Health Survey 12, PEDSQL®: Pediatric Quality of Life Inventory

Table 5: Peer effects analysis – regression results for change in zBMI

	Fixed Effects model			IV Fixed Effects Model 1			IV Fixed Effects Model 2		
	B	SE	p	B	SE	p	B	SE	p
Change (zBMI peers)	0.167	0.072	0.023	0.796	0.356	0.029	0.779	0.373	0.041
Child zBMI baseline	0.029	0.011	0.008	0.032	0.010	0.002	0.032	0.010	0.002
Parental BMI baseline - child							0.000	0.0004	0.467
Peer zBMI baseline	-0.027	0.019	0.157	-0.029	0.018	0.103	-0.029	0.017	0.097
Attendance (%)	-0.001	0.0002	<0.001	-0.001	0.0003	0.004	-0.001	0.0003	0.004
N	2633			1940			1940		
Instructor Fixed Effects	Yes			Yes			Yes		
First Stage F-statistic				33.860			32.106		

BMI: Body Mass Index, zBMI: BMI z-score, SE: Standard Error, IV: Instrumental variable (Parental BMI baseline - peer)

Jackknife clustered standard errors

Figure 1: Study flow chart