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## Advances in Motivational Interviewing for Pediatric Obesity: Results of the BMI<sup>2</sup> (Brief Motivational Interviewing to Reduce Body Mass Index) Trial and Future Directions

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## INTRODUCTION

Rates of childhood obesity in the US remain at historic highs, in particular, Class III obesity (BMI greater than 140% of the 95th percentile) appears to be on the rise<sup>1,2</sup>. The medical, economic, and social costs of pediatric obesity are massive and well documented<sup>3–7</sup>. Ameliorating childhood obesity rates in the US requires concerted intervention at multiple

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### DISCLOSURE STATEMENT

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levels, e.g., policy, community, schools, and health care settings<sup>3</sup>. The pediatric primary care office represents an important yet still underutilized setting to intervene with families<sup>8</sup>. Pediatric practitioners believe that they should be involved in the detection, prevention, and treatment of childhood overweight/obesity, yet counseling rates remain suboptimal<sup>9</sup>.

One factor contributing to the underuse of the primary care (PC) setting to prevent and treat pediatric obesity is the lack of effective interventions available to clinicians. Positive intervention effects have been reported in family-based behavioral obesity treatments implemented (often by behavioral rather than medical professionals) outside of PC<sup>10–15,16</sup>, however, results of most treatment studies in primary care<sup>17–21</sup> have not shown significant effects on adiposity in primary analyses (a few found effects for subgroups)<sup>12,17,22–28</sup>. A second barrier is that primary care practitioners feel they lack the skills needed to engage and motivate parents and families<sup>9,29–32</sup>. Fully 80% of PCPs report feeling “very frustrated” treating pediatric obesity<sup>33</sup>. Thus, developing and testing interventions for the primary care setting that specifically help improve PCPs motivational and behavior change skills is a high priority.

One evidence-base method to help engage and motivate patients is Motivational Interviewing (MI). MI integrates client-centered and goal-oriented styles of counseling, that has been used extensively to modify health behaviors in adults including obesity. MI is recommended for the prevention and treatment of pediatric obesity<sup>34,35</sup>; however its efficacy in pediatric obesity has only been examined in a few, generally small scale studies, with mixed results<sup>17,23,36–41</sup>.

Many counseling models rely heavily on directive advice and information exchange. In contrast, in MI, clients themselves do much of the psychological work. An MI counselor generally avoids direct attempts to convince or persuade, and is careful not to begin action planning before strong, high quality motivation is solidified. Clients are encouraged to think about and verbally express their own reasons for and against change and how their current behavior impacts their life and family goals and core values. Ambivalence and resistance are explored prior to moving toward action. An effective MI practitioner is able to strategically balance the need to “comfort the afflicted” and “afflict the comfortable”; to balance the expression of empathy with the need to build discrepancy for change; and to disrupt the defenses that have been built around the problem behavior<sup>42,43</sup>.

Whereas the essence of MI lies in its spirit, specific techniques help ensure such spirit is evoked. Two central skills to achieve this are reflective listening and eliciting change talk. **Reflective listening** can be conceptualized as a form of hypothesis testing. The hypothesis can be stated in generic terms as “*If I heard you correctly, this is what I think you are saying or why are you saying this...*” or “*Where you might be going with this.*” The goals of reflecting include demonstrating empathy and understanding and affirming the client’s thoughts and feelings. MI assumes that individuals are more likely to act upon that which they voice themselves<sup>44</sup> and they can be guided to help uncover powerful reasons for change through the counseling process. This expression of desire and reasons for change is called **change talk**<sup>45</sup>. Eliciting and reinforcing change talk has emerged as an essential active ingredient of MI<sup>46–51</sup>. Evidence for the causal role of change talk includes the association

between the amount and trajectory of client change talk expressed within session and subsequent behavioral outcomes<sup>47,52–55</sup> as well as studies demonstrating that specific therapist behaviors (and training activities) can facilitate its expression<sup>46,48,49,52,53,56</sup>.

Interventions that provide PCPs skills in motivational and behavioral counseling could help fulfill the promise of primary care as an important setting to deliver pediatric obesity counseling. This paper summarizes the methods, outcomes and process and from the BMI<sup>2</sup> study, a large trial conducted in primary care pediatric offices, and concludes with recommendations for improving the intervention and increasing its dissemination.

## METHODS

**The Brief Motivational Interviewing to Reduce Body Mass Index (BMI<sup>2</sup> study)** (2007–2013) was a cluster- randomized trial among 42 primary care practices<sup>18,19</sup> that tested two MI interventions of varying intensity compared to a minimal intensity/Usual Care Group. Clinical practices served as the unit of randomization and analysis. **Group 1 (Usual Care)** measured BMI percentile at baseline, 1-year, and 2-year follow-up with routine care by the PCP<sup>18</sup>. Group 1 PCPs received a 1/2 day study orientation and a review of current pediatric obesity guidelines<sup>35,57</sup>. At the end of the study, Group 1 PCPs received complete MI training. **Group 2** included the same assessments as Group 1. In addition, Group 2 PCPs received 1.5 days of training in MI and Behavior Therapy (BT) as well as an MI booster training DVD. Group 2 PCPs were asked to schedule 3 MI sessions with a parent of the index child in Year 1 and one additional “booster” visit in Year 2, although they were given latitude in appointment scheduling. To guide their counseling they were provided with a food and activity screener which is described below<sup>19</sup>. **Group 3 (PCP+RD)** included the same intervention as Group 2, but added MI counseling from trained RDs linked to each practice, who were asked to deliver 6 MI counseling sessions over 2 years. RDs were given flexibility with scheduling, although they were encouraged to frontload contacts in Year 1. The RD sessions were delivered both in-person (required for visit 1) or by phone. RDs received 1.5 days of MI and BT training, and the MI DVD<sup>18,19</sup>. They were trained together with their partner PCPs for most of the MI training, although there were a few breakout sessions for RDs only.

## Outcomes

The primary outcome was the child’s BMI percentile at 2-year follow up. Secondary outcomes included parent report of the child’s screen time, physical activity, intake of fruits and vegetables, and sugar sweetened beverages. We also assessed parental self-reported grades for key obesity-related behaviors.

**Parent Questionnaire.** Parents in all groups completed a questionnaire at baseline, one-year and two-year follow-up. The questionnaire assessed secondary behavioral outcomes, and for Groups 2 and 3 also provided both the PCPs and RDs with discussion starting points for their behavioral counseling<sup>18</sup>. *Intake of Sugar Sweetened Drinks* was assessed by querying: “How many glasses or 12 oz. cans of each beverage does your child drink on a typical day?” There were four options; fruit drinks, sports drinks, regular soda, and sweet tea. For *Physical Activity* we asked: “On a typical weekday/weekend day, how many hours is your child

involved in sports or active play?" *Screen Time* was assessed with, "How many hours of TV does your child watch on a typical weekday/weekend day including evenings?" And, "How many hours of video games does your child play on a typical weekday/weekend day including evenings. Weekend and weekday hours were averaged to estimate total screen time per day<sup>18</sup>. *Fruit and Vegetable Intake* was assessed with "How many servings of fruits (excluding juice) does your child eat on a typical day?" And "How many servings of vegetables (excluding potatoes) does your child eat on a typical day?" The two items were summed. Most measures were used in BMI<sup>2</sup> were adapted from existing instruments. More details about our measures can be found elsewhere<sup>18</sup>.

**Parent Grade of Child Behavior.** We asked parents to grade their child on a scale from A (great/healthy) to F (poor/unhealthy) for eight behaviors; snack foods, sweetened beverages, eating out at restaurants, fruits, vegetables, TV/ screen time, video games/computer games, and physical activity/exercise. We coded all responses as "A" or not "A", and used this as a secondary outcome, comparing the odds of responding A versus all other grades combined<sup>18</sup>.

**Demographics.** Parents reported household income using eight contiguous categories which were collapsed into "less than \$40,000" and "greater than or equal to \$40,000". Education was assessed with seven categories, which were collapsed into "less than college graduate" and "college graduate or greater". We queried insurance coverage first by asking if the child had any insurance, and then by asking about specific types, e.g., private, Medicaid. These variables were used as covariates and potential effect modifiers.

**The target population** was children ages two to eight years old with a BMI > 85th and < =97th percentile based on CDC cutpoints<sup>58</sup>. We excluded youth above the 97th percentile of BMI because of concern that at higher levels of BMI, many clinicians would initiate metabolic screening and likely refer the child to a specialist, which would likely differ across practices, introducing a potential confound.

**Exclusion Criteria** were Type 1 or Type II diabetes, non-English speaking parent, no working telephone, child with chronic medical disorders, chromosomal disorders, syndromes and non-ambulatory conditions, medications known to affect growth and mood, enrollment in a weight loss program or seen by weight loss specialist in past 12 months. Eligibility was initially determined by the study practices and then confirmed by the study team. Those enrolled by practices but subsequently found to be ineligible by the study team were allowed to continue in the study, but their data was excluded in all analyses.

## Study Sites

All practices were recruited from the Academy of Pediatrics' Pediatric Research in Office Settings (PROS) network. Established by the AAP in 1986, PROS is the largest pediatric primary care research network in the nation, comprising over 1,600 practitioners from over 700 pediatric practices. PROS practitioners are similar to their broader counterparts, with respect to vision screening<sup>59</sup>, management of child behavior problems<sup>60</sup>, and specialty referrals<sup>59,61,62</sup>.

We approached PROS sites that had previously participated in at least one prior research project, excluding; 1) Sites that offered a structured obesity treatment program, and 2) Clinicians with extensive experience with MI. Each practice identified an office staff member who served as the local study coordinator and this person attended the protocol training. Practices were asked to enroll at least 20, and up to 25 eligible children. Given the higher rates of overweight and obesity in minority children, we oversampled practices with at least 25% Black and/or Hispanic patients. Our goal was to accrue approximately 25% Black and 25% Hispanic patients.

### Identifying and Recruiting Dietitians

Registered dietitians (RDs) for Group 3 were selected from a registry of practicing dietitians within the Academy of Nutrition and Dietetics' Practice-Based Research Network. RDs were paired with a practice. Potential RDs were interviewed to assess their potential for implementing MI using a simulated patient encounter. A total of 15 RDs were recruited and trained in MI.

### MI Training

We used a mix of didactic and experiential activities, following the “reveal-practice-reveal” model, with real time constructive feedback. Rather than positioning MI as an entirely new model for PCPs and RDs, we integrated MI into their current counseling “culture.” For pediatricians, we demonstrated how to integrate MI within the “culture” of anticipatory guidance whereas for RDs, we discussed integration of MI within traditional nutrition counseling. The 1.5 day training included the following components:

1. Conceptual overview of MI: its spirit and essential strategies
2. Comparison of MI to other models of counseling and patient education
3. Conceptual application of MI to prevention and treatment of pediatric obesity
4. Integration of MI with anticipatory guidance and nutrition counseling
5. Constructing effective open-ended questions
6. Reflective listening
7. Eliciting change talk using 0–10 importance and confidence rulers and values clarification
8. Providing information and advice MI-style (aka Elicit-Provide-Elicit)
9. Counseling by telephone (for RDs)

Emphasis was placed on eliciting and magnifying change talk from parents, and clinicians were given several techniques to do so. First, they were trained to use the importance/confidence rulers<sup>45,63–65</sup>. This begins with two questions: 1) “On a scale from zero to ten, with ten being the highest, how **important** is it for you to have your child [insert behavior of choice]” and 2) “On a scale from zero to ten with ten being the highest, assuming you wanted to change this behavior, how **confident** are you that they could?”<sup>63–65</sup>. Counselors then probed with “Why did you not choose a lower number?”, followed by “What would it

take to get you to a higher number?” . A second technique to elicit change talk was the value linkage<sup>45</sup>. For this, parents were given a list of values for themselves and their families, then asked, how if at all, they might connect their child’s physical activity and diet behaviors to their personal and family goals and values<sup>18,42,43</sup>. A key challenge for MI clinicians is determining when and how to transition from building motivation to planning a course of action. To this end, we trained PCPs and RDs in a three phase model of MI comprising: *Explore*, *Guide*, and *Choose*<sup>18,42,43,66,67</sup>. This three phase model is similar to the “four process” model recently proposed by Miller and Rollnick<sup>51</sup>. To help PCPs and RDs experience the benefits of MI, they were asked during practice exercises to use behaviors from their own lives to gain insight about what their patients may experience when they are being counseled. There is considerable evidence that health professionals can effectively implement MI with this type and intensity of training<sup>68–77</sup>.

### Assessing Practitioner Fidelity

At the end of the 1.5 MI training all PCPs and RDs counseled a standardized patient, typically played by study staff. These encounters were video-taped and rated with a validated MI fidelity scale (available from the first author)<sup>78</sup>. While clinicians were at the training, they received detailed feedback from study staff about their counseling encounter. Practitioners were offered an additional supervision session by telephone. All Group 2 and 3 practitioners who completed the training, regardless of skill level, were allowed to participate in the trial.

**Target Behaviors and Intervention Strategies in Groups 2 and 3**—Both PCPs and RDs focused their counseling on dietary and activity behaviors shown to affect children’s weight<sup>34,80–82</sup> based on Academy of Nutrition and Dietetics and other evidence-based guidelines<sup>83,34</sup>. We targeted; snack foods, sugar sweetened beverages, fruits, vegetables, screen time, and physical activity. Target behaviors were identified with the brief screener discussed above. For each of these targets parents indicated the frequency of the behavior as well as their family grade (A through F). PCPs were asked to provide positive feedback for “green” behaviors and then collaboratively with the parent, identify red or yellow behaviors that might be addressed during the project. RDs were provided with a copy of the parent baseline questionnaire responses prior to their first session. Group 3 PCPs and RDs were given a form to record their patient encounters which, to promote continuity of care, were shared by providers.

### Educational Materials

Group 1 PCPs distributed a set of mostly pre-existing, educational materials that addressed healthy eating and exercise. All Group 1 parents received the same set of materials. For Groups 2 and 3, either pre-existing materials or new materials that were written in a style consistent with MI and Self-Determination Theory<sup>84</sup> were used. Content emphasized child choice in making behavior change. Groups 2 and 3 also were offered self- monitoring logs for the child and/or parent to complete. For Groups 2 and 3, clinicians offered only the educational materials and logs that were either requested by the patient or that related to the target behavior change that was chosen by the family.



### Sample size calculations

The study was powered to detect a three-point difference in BMI percentile between any pair of study groups at two-year follow-up, with an assumed standard deviation for BMI percentile between four and six; power of .80 and two tailed alpha of .05. We inflated our sample size to account practice level clustering<sup>85</sup>, assuming a practice level intra-class correlation between .01 and .05. Based on these assumptions and projected 25%- 30% attrition at two-year follow-up, we required 10–12 practices per arm (30–36 total) and an average of 15–20 children per practice at baseline.

### Outcome analysis

The primary outcome was BMI percentile at 2-year follow-up. To control for cluster randomization effects, we utilized mixed effects regression with children nested within their practice. Although the primary analyses are based on intention to treat, we also provide post-hoc exploratory results stratified by “low” and “high” dose MI received for Groups 2 and 3. We used 75% of the expected dose (3 sessions for Group 2 and 8 sessions for Group 3) as the cutoff for “low” and “high” MI exposure.

We also examined mean differences in parent reported child behaviors as well as the odds (using logistic regression) of parents assigning their family an “A” grade for each target behavior. Initial covariates included in all outcome models were child age, sex and gender, baseline value for the variable of interest, as well as all variables that differed between study groups at baseline. Covariates unrelated ( $p > .10$ ) to the outcome were removed from the final model.

## RESULTS

### Sample Description

Mean baseline BMI percentile was 91.9, with values similar across the three experimental groups. Mean age was 5.1, with Groups 2 and 3 recruiting older children than Group 1. Parent BMI, calculated from self-reported heights and weights, was highest in Group 2. The child sample was 57% female and 91% of the responding parents were mothers. Groups 2 and 3 had a greater percentage of mothers as respondents than Group 1. With regard to ethnicity/race, the cohort was 60% white, 22% Hispanic, 7% Black, and 6% Asian, and the three groups differed significantly with regard to ethnic/racial composition. Overall, around 68% of parents reported household income at or above \$40,000 per year, with Group 2 significantly less likely to report > \$40,000 income. Around 39% of the sample reported at least a college education, with Group 2 having lower rates than Groups 1 and 3. Group 2 was less likely to have private insurance and more likely to have Medicaid coverage. Data not shown.

A total of 674 participants were recruited. *We were unable to collect data about the number of parents who refused to participate so we cannot provide the study uptake rate.* Of these, 29 were ineligible because their BMI percentile, when verified by study staff, was outside the eligible range. They were allowed to continue in the project but their data were excluded. Of the original 42 practices, one Group 1 practice was excluded for not following the

protocol; three Group 2 practices dropped out (1 PCP passed away, 1 retired, and 1 declined to recruit any patients) and 1 Group 3 practice dropped out due to medical illness.

Of the 645 eligible baseline children, two-year follow-up BMI data were obtained for 457 (71%). The retained cohort was similar to those lost to follow-up with regard to BMI percentile, age, and gender. However, those lost to follow-up were significantly more likely to be Black or Hispanic, to come from households with < \$40,000 income and lower parental education. They were also more likely to have Medicaid. Parents lost to follow-up had higher baseline self-reported BMI. The intra-class correlation of Year 2 BMI percentile due to practice level clustering was 0.04. Data not shown.

### MI Dose in Groups 2 and 3

The expected dose from PCPs in Groups 2 and 3 was 4 sessions, and for Group 3, 6 additional sessions from the RDs (10 total). The mean MI dose for PCPs was 3.4 and 3.3 in Groups 2 and 3, respectively<sup>19</sup>. For Group 2, 83% of PCPs delivered 3 or more sessions while in Group 3, 75% delivered 3 or more. Thus, PCPs were able to deliver the expected dose of MI counseling. However, for Group 3 the mean dose for RD contacts was only 2.7 (out of 6). For RDs, only 12% delivered all 6 sessions, with 20% delivering 4–5 sessions. Parents were given a choice as to in-person or telephone for conducting contacts 2–6, and the majority of these contacts, 79%, were by completed by telephone.

### BMI Percentile Results

At two-year follow-up, the adjusted BMI percentile was 90.3, 88.1, and 87.1 for Group 1, Group 2, and Group 3 respectively<sup>19</sup>. There was an overall group effect,  $p = 0.049$ . Planned contrasts showed that Group 3 was significantly ( $p = .02$ ) lower than Group 1. The Group 2 mean was marginally lower than Group 1 ( $p = .11$ ). The net difference in BMI percentile between Groups 3 and 1 was 3.2 BMI percentile units and 2.2 percentile units between Groups 2 and 1.

Using individual level difference score in BMI percentile (baseline – year 2), means were 1.8, 3.8, and 4.9 BMI percentile units across Groups 1, 2, and 3, respectively, with significance patterns virtually identical to that observed using BMI percentile. The net difference using this method, between Groups 3 and 1 was 3.1 BMI percentile units and 2.0 percentile units between Groups 2 and 1.

Using raw BMI units, the difference between Group 1, and Groups 2 and 3, was .5 and .6 BMI units, respectively (see last column in Table 2.)

Neither child sex, child age, child race, baseline BMI, parent income, parent education, or parent BMI moderated intervention effects.

**Dose-Response Effects.**—Exploratory “completers” analyses indicated that across the five groups, i.e., usual care, “low” PCP dose, “high” PCP dose, “low” PCP + RD dose, and “high” PCP + RD dose, the mean changes in BMI percentile scores were 1.7, 3.2, 4.2, 4.6, and 5.5. Both Group 3 High and Low dose means were significantly greater than Group 1. Neither Group 2 High or Low means differed from Group 1.



## Secondary Outcomes

Parent self-reported fruit and vegetable intake of the index child was significantly higher in Group 3 than Group 1. See Table 4. Hours of screen time were significantly lower in Group 3 compared to both Groups 2 and Group 1. Values for physical activity and sweetened beverages generally favored Group 3 but the differences were not significant.

Parents self-reported grade for their family's target behaviors are reported in Table 5. For all behaviors, the odds of parents reporting an "A" grade were higher for Group 3 than Group 1, and were statistically greater than 1.0 for fruit intake and physical activity. Odds of an "A" grade were higher in Group 2 than Group 1 for all but physical activity and screen time, but they were not statistically different than 1.0.

## PROCESS EVALUATION OF BMI<sup>2</sup>

### Parent Survey Data.

At the end BMI<sup>2</sup>, we collected surveys from 280 parents (125 Group 2 and 155 Group 3); the two groups that received the MI intervention). We asked both closed and open questions about various aspects of their study experience. Overall satisfaction with the program was high, with 80% answering somewhat/very satisfied with their experience. In terms of rating the MD and RD counseling, as shown in Table 6, responses were generally positive, although somewhat more so about the MD than RD counseling.

### Parent Open-Ended Response.

Key findings from open-ended items included a desire for more flexible times to participate in the RD phone counseling as well as a request for "booster" messages, ideally electronic (either SMS or emailed).

### RD Interviews.

We contacted all study RDs to complete a semi-structured interviews focusing on elucidating the low MI completion rates in Group 3. Responses were obtained from 7 (out of 13 study completers) RDs. Key issues we identified were; 1) providing parents with more evening and weekend hours to receive the RD counseling, 2) improving data sharing between RDs and PCPs, perhaps using a shared electronic record, 3) improving call tracking for the RDs, and 3) improving PCP endorsement of the RD counseling component.

### PCP Interviews.

Seven of the 10 UC PCPs were interviewed at their post-study MI training. We did this in part to elucidate the larger than expected BMI changes in the UC group. We did not have sufficient resources to interview Group 2 and 3 PCPs. Among UC PCPs, we found one practice added an RD to their staff during the trial and one noted that their patients were motivated to lose weight "to make their doctor look good."

## DISCUSSION AND FUTURE ENHANCEMENTS TO BMI<sup>2</sup>

The BMI<sup>2</sup> intervention achieved statistically significant, and clinically meaningful<sup>86,87,88</sup> reductions in BMI percentile between Groups 3 and 1, and borderline significant effects between Groups 2 and 1. These effects are to our knowledge the largest reported for a PC intervention<sup>12,17,22–27</sup>. One reason for the lack of effects between Groups 1 and 2 was the larger than expected change in the usual care group. Additional discussion of this issue can be found elsewhere<sup>19</sup>. Although the results were promising, the effects observed may have been attenuated by the lower than expected intervention dose by the Group 3 RDs. Even stronger intervention effects were observed for the subset of families that completed the RD intervention. Our process analyses identified several potential means to enhance intervention uptake and thereby its efficacy. Below we discuss four suggestions for improving the BMI<sup>2</sup> model; 1) Adding text messaging, 2) Moving the RD counseling to a centralized disease management system, 3) Integrating BMI<sup>2</sup> into electronic health records, and 4) Providing practitioners with real time feedback regarding their counseling via a natural language processing system.

### 1) Text Messaging to Boost Intervention Effects, Enhance Engagement, and Reduce Attrition

One means to enhance impact and uptake of the BMI<sup>2</sup> intervention recommended by parents and practitioners was to add supplemental text messaging. Text messaging (SMS) and related E-health interventions have increasingly been used to improve adherence to appointments and to deliver motivational and behavior change messages<sup>89–114</sup>. For BMI<sup>2</sup> SMS could be used to provide reminders to schedule and complete MI calls as well as deliver behavioral and motivational messages such as goal attainment and reminders for the reasons parents and youth would benefit from controlling their weight. SMS can also be used to help track goal attainment and self-monitoring behavior changes.

### 2) Move RD Counseling to a Centralized Telephonic Disease Management System

A major limitation of BMI<sup>2</sup> was the relatively low rate of call completion by the RDs who were linked to each primary care practice. One means to improve the uptake of the RD counseling is to move this intervention component to a centralized disease management system. Increasingly, disease management (DM) programs are being conducted telephonically<sup>115–120</sup>. Telephone DM counseling has been used to address a wide range of health issues including medication adherence<sup>121,122</sup>, diabetes control<sup>123–127</sup>, heart failure<sup>120,122,128</sup>, smoking cessation<sup>129</sup>, and adult weight management<sup>130–136</sup>. Many health care delivery systems including the Veterans Administration<sup>126,131,137</sup>, integrative health care delivery systems<sup>129,138,139</sup>, and both Medicare and Medicaid<sup>121–124,140</sup> use DM to manage chronic disease, and this approach appears to be increasingly utilized across the health care delivery system<sup>139,140</sup>. Few pediatric obesity studies have included telephone components<sup>23,141</sup>. Most have relied on practice staff to deliver the intervention rather than professionally trained, and centrally supervised personnel. In one prior study as well as the BMI<sup>2</sup> study, parent satisfaction in one study did not differ when delivered face to face or by telephone.<sup>142</sup> Importantly, parent satisfaction in BMI<sup>2</sup>, did not differ whether the RD counseling was delivered by phone or in person. Also, telephonic DM programs appear to be

more cost-effective for than in-person counseling.<sup>126,130,137,143</sup> Advantages of a centralized DM system include; 1) Use of dedicated, highly trained RDs who will be supervised centrally, 2) Lower per session costs than in-person office-based intervention, and 3) Greater scheduling flexibility for patients, and thereby greater appointment adherence.

### 3) Integration of BMI<sup>2</sup> into Electronic Health Records.

The electronic health record offers several potential opportunities to enhance the impact of the BMI<sup>2</sup> and similar interventions. Prompts can be provided to remind physicians to engage parents of children with elevated BMI (BMI is typically included in most EHRs already). Modules can be added that provide clinicians with tips (sample questions and reflections, 0–10 scales, and values lists) for using MI as well as checklists to document what was discussed during the encounter. In addition, intervention materials (e.g., behavioral tips, self-monitoring tools) for parents can be incorporated into the EHR and sent to patients via a patient portal or other distribution mechanisms. A recent study by Taveras et al demonstrates the potential benefit of such “systems” level intervention<sup>20</sup>.

### 4) Natural Language Processing to Automatically Code Clinician Responses

At the end of the two-day training for BMI<sup>2</sup> all clinicians completed a standardized patient session and they were provided immediate feedback about their skills. However, we did not have the ability to provide ongoing monitoring and supervision of clinicians throughout the study. In part, this was due to the effort, cost, and logistics required to provide human feedback to our clinicians. A potential solution to address this problem is to provide feedback through an automated computer system designed to perform real time rating of clinician behaviors and summarize relevant aspects of the patient-counselor interaction. This can be accomplished through Natural Language Process (NLP). NLP is a discipline that applies computational models to understand and process text and speech data. Here, we report on a preliminary proof of concept study using NLP to code responses by MI counselors and then compare these to code from human raters using MITI 4.0 rating system.. A few prior studies have examined computer-based techniques for analyzing motivational interviewing encounters<sup>144,145</sup>.

In this pilot study, we focused on using NLP analyses of linguistic patterns to code two core MI responses; Reflections and Questions. The research was completed in three steps. First, we built a data set of MI encounters coded with the MITI 4.0 system. Second, we used NLP methods to extract and analyze linguistic patterns associated with responses coded as reflections and questions by the MITI raters. Third, we developed an automatic system able to predict behavior codes and evaluate MI interventions.

## Methods

The dataset is based on 284 audio recordings of MI counseling encounters from various sources, including counseling sessions from clinical trials for smoking cessation and medical adherence, students’ counseling sessions from a graduate level MI course, telephone health coaching calls, and demonstrations of MI strategies in brief medical encounters. The dataset consists of a total of 97.8 hours of audio recordings with an average session duration of 20.8 minutes. Each session was transcribed and annotated by one of three coders using the MI

Treatment (MITI) coding system. During the transcription process, some sessions were excluded due to recording errors, leaving 277 sessions, which were randomly distributed among the three coders. The annotation was conducted at utterance-level by manually selecting and labeling the utterance for the specific MI behavior present in that utterance.

Once the annotation was completed, the data was processed to extract the verbal content. The final set contains 15,886 counseling behavior annotations distributed among ten MITI codes as follows: 5262 Questions, 2690 Simple Reflections, 2876 Complex Reflections, 614 Seeking Collaboration, 141 Emphasizing Autonomy, 499 Affirm, 141 Confront, 598 Persuading without Permission, 1017 Giving Information, and 2100 Persuading with Permission. Here we report our results only for reflections (combining complex and simple) and questions.

### Reliability of the Human Coders

Coding reliability was measured in a sample of 10 double-coded sessions, which contained a total of 546 annotations. In order to compare annotations for each MI behavior, we first extracted all the annotations from each coder and paired them at utterance level. Since the coding was performed without previous pre-parsing we addressed parsing differences by applying utterance-matching methods that dealt with differences in utterance boundaries and with utterances split among two codes. An annotation match was assigned when both coders agreed on their evaluations. Utterances for which we were unable to find a matching pair or differed on the assigned codes were regarded as disagreements. For this pilot study, we measured the coders reliability for reflections and questions, the Intraclass Correlation Coefficient (ICC) was measured at 0.97, 0.82 and 0.89 for Questions, Simple Reflections, and Complex Reflections respectively. Their pairwise agreement using Cohen's Kappa metric, which accounts for the probability of agreement by chance, was 0.64, 0.34, and 0.39 for Questions, Simple Reflections, and Complex Reflections respectively.

### Statistical classification of MI behaviors

In order to explore the linguistic patterns for Reflections and Questions, we analyzed the verbal content of the samples for each behavior using the following linguistic features:

**N-grams:** These features represent the language used by the counselor and include all the unique words and word-pairs present in counselor speech while making reflective statements or questions. For instance, words and word pairs such as *sounds, like, feeling, change, to, sounds-like, feeling-like, to-change* form part of reflections language. To obtain these features, we first build a vocabulary containing all the unique words from all the behavior annotations, and then we count the frequency of each unique word and word pair in each annotation. Thus, we obtain a vector containing the frequencies of each word and word pair in the annotation.

**Semantic information:** Semantic features attempt to bring semantic meaning into the analysis of counselor language by identifying words belonging to specific semantic categories, for instance, tentative language: *maybe, perhaps, guess, looks*; anxiety words: *afraid, tense, worried*. We use two different groups of semantic features. The first consists of

features derived from the LIWC lexicon<sup>143</sup>, a psycholinguistic resource that contains word classes that represent psychological cues to human thought processes, emotional states, intentions, and motivations. The second is a self-acquired MI lexicon that was created by compiling a set words frequently present during reflective statements created by our team. These features are represented the total frequency counts of all the words in a word category that are present in counselor language.

**Similarity:** Since reflective listening includes repetition and rephrasing, we can expect to observe linguistic similarity between client and counselor speech. Thus, we measured the degree to which the counselor matches the client language by using Linguistic Style Matching<sup>144</sup> (LSM), a computational linguistics technique that allows to quantify the extent in which one person use comparable types of words than the other. We measure LSM at turn-by-turn level using the LIWC word categories e.g., positive words, articles, pronouns, negations, quantifiers. In order to capture information from return statements, we combine client speech from the previous and current turn along with the counselor speech corresponding to the current turn. Each of these features are represented by a score ranging between 0 and 1 that indicate the degree in which the counselor and client use the same type of words. For instance, if the feature is *anxiety*, a score close to 1 indicates counselor and client have high degree of style matching on the use of anxiety words, which represent cases where the counselor is simply repeating the same word i.e. client utterance “I’m worried that ...”, counselor utterance: “you are worried”, or rephrasing with a synonym or related word e.g. “you are overwhelmed ...”.

**Deep syntax:** These features reflect the syntactic structure of the counselor statements. We use these features to encode information about the word order in the sentence. First, we represent a sentence using its dependency tree, a representation that indicates the grammatical relations between words. For instance, in the following counselor utterance: “you feel sad”, first each element in the sentence is assigned a speech tag, i.e. *you* (pronoun), *feel* (verb), *sad* (adjective). Then the relations between the words are: pronoun→*you*, verb→*feel*, adjective→*sad*, nounPhrase→pronoun, verbPhrase→ verb +adjective, sentence→nounPhrase+verbPhrase. Using this strategy, we analyze all the annotations to find the most frequent syntactic patterns in counselor reflections and questions. We expect that these patterns will likely capture reflection starters commonly used by the counselor such as “*it sounds like you ...*”. Each pattern then is represented as a feature by counting how many times it occurs in the given sample.

After the feature extraction, we explore if these features can be used as predictors for Reflections and Questions using the MITI code as the reference standard. We thus perform a binary prediction task where we classified annotations as either a Reflection (either Simple or Complex), or a non-reflection (i.e., statements labeled with any other MITI code). We repeated this for Questions. We use a Support Vector Machines<sup>145</sup> (SVM) classifier, which is an algorithm that uses a set of training examples marked as belonging to one of two categories, e.g., reflection and non-reflections, to build a model that learns a linear separation function that assigns new examples into one category or another. We build several classification models using each of the features sets described above. We evaluated how each

method was able to correctly identify Reflections or Questions compared to MITI codes, using four standard classification measures: 1) *Precision*, defined as the number of correctly predicted Reflections or Questions by the NLP compared to the MITI code for that corresponding text, divided by the total number of each code predicted by NLP as Reflections or Questions (This is similar to true positives), 2) *Recall*, which is the number of correctly identified Reflections or Questions by NLP compared to MITI, divided by the total number of Reflections or Questions identified by MITI codes, 3) *F1 score*, which is the harmonic mean of precision and recall; and 4) *Accuracy*, defined as the sum of true positives and true negatives, divided by the total number of all codes, i.e. percentage of reflections and non- reflections (or, questions and non-questions) correctly identified by NLP method..

In addition, each classifier was evaluated using a five-fold cross-validation, thus we report the average of five runs where we build the model using 80% of the data and test on the remaining 20%. Table 7 shows the classification results for both, Reflections and Questions. As reference value, we use a majority baseline, which is the percentage of instances correctly classified when selecting by default the most frequent category in the training data. For instance, given that 10,320 out of 15,886 training samples are non-reflections, the majority baseline for Reflections is 64%. Also, since we develop the semantic and similarity features specifically for Reflections, these features are not used to predict Questions.

Results show that detecting reflections by automatic means yields good performance. Reflections accuracy ranged from 63 to 87% while questions detection accuracy ranged from 54 to 91%. Syntactic structure was a good predictor of Questions and Reflections as the *Deep syntax* model shows the best trade off between precision and recall with F-scores of 84% and 87% respectively. Overall, these experiments support the use of automatic means to predict counselor behavior. Our next steps in this research include using NLP to predict global scores, such as empathy and building a tool to provide clinicians with real time feedback based on the NLP analyses.

## Closing

In addition to the issues discuss above, bringing the BMI<sup>2</sup> intervention to scale will also require that we address some other key challenges including; 1) how to deliver the MI training component across large health systems, perhaps using web-based or telehealth strategies, 2) maximizing reimbursement for providers from both government and private payers, 3) adapting the intervention to current policy changes and the evolving health care delivery system, such as requirements set forth in the Affordable Care Act.

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**KEY POINTS**

- Rates of childhood obesity in the US remain at historic highs.
- The pediatric primary care office represents an important yet still underutilized setting to intervene with families.
- Motivational Interviewing is an evidence-base method to help engage and motivate patients.
- The Brief Motivational Interviewing to Reduce Body Mass Index (BMI<sup>2</sup> study) tested two MI interventions of varying intensity compared to a minimal intensity/Usual Care Group. Group 1 (Usual Care) measured BMI percentile at baseline, 1-year, and 2-year follow-up with routine care by the PCP. Group 2 included the same assessments as Group 1. In addition, Group 2 PCPs received 1.5 days of training in MI and Behavior Therapy (BT) as well as an MI booster training DVD. Group 2 PCPs were asked to schedule 3 MI sessions with a parent of the index child in Year 1 and one additional “booster” visit in Year 2, although they were given latitude in appointment scheduling. Group 3 (PCP+RD) added MI counseling from trained RDs linked to each practice, who were asked to deliver 6 MI counseling sessions over 2 years..
- The BMI<sup>2</sup> intervention achieved statistically significant and clinically meaningful reductions in BMI percentile between Groups 3 and 1.
- Key improvement for future related interventions may include centralized delivery of the RD counseling, supplementing counseling with SMS, and automated systems to provide clinicians with real time feedback.

**SYNOPSIS**

Rates of childhood obesity in the US remain at historic highs. The pediatric primary care office represents an important yet still underutilized setting to intervene with families. Pediatric practitioners believe that they should be involved in the detection, prevention, and treatment of childhood overweight/obesity, yet counseling rates remain suboptimal. One factor contributing to the underuse of the primary care (PC) setting to prevent and treat pediatric obesity is the lack of effective interventions available to clinicians. One evidence-based method to help engage and motivate patients is Motivational Interviewing (MI). MI is a client-centered and goal-oriented style of counseling that has been used extensively to increase autonomous motivation and modify health behaviors. However its efficacy in pediatric obesity has only been examined in a few, generally small scale studies, with mixed results. This paper summarizes the methods and results from the BMI<sup>2</sup> study, a large trial implemented in primary care pediatric offices, and concludes with recommendations for improving the intervention and increasing its dissemination.

**Table 1.**Number and Percent of MI Sessions Completed by Intervention Group in BMI<sup>2</sup>

STUDY GROUP	NUMBER OF COMPLETED MI CONTACTS						
	0	1	2	3	4	5	6
<b>GROUP 2 PCPs</b> (n =145)	3 2.1%	14 9.7%	8 5.5%	14 9.7%	106 73.1%	NA	NA
<b>GROUP 3 PCPs</b> (n =154)	3 1.9%	18 11.7%	17 11.0%	12 7.8%	104 67.5%	NA	NA
<b>GROUP 3 RDs</b> (n =154)	21 13.6%	24 15.6%	29 18.8%	30 19.5%	22 14.3%	9 5.8%	19 12.3%

**Table 2.**Year 2 adjusted BMI Percentile<sup>19</sup> MI Percentile, Percentile Change, and Raw BMI by Study Group BMI<sup>2</sup>

Study Group	n	Year 2 BMI Percentile <sup>^</sup> (SE)	BMI Percentile Difference <sup>#</sup> (SE)	Raw BMI
Group 1	158	90.3 <sup>1</sup> (0.94)	1.8 <sup>1</sup> (0.98)	19.75 <sup>1</sup> (0.17)
Group 2	145	88.1 (0.94)	3.8 (0.96)	19.33 (0.18)
Group 3	154	87.1 <sup>1</sup> (0.92)	4.9 <sup>1</sup> (0.99)	19.17 <sup>1</sup> (0.17)

Groups with common superscript differ  $p < .05$ , # - Subtracting Year 2 BMI percentile from Baseline BMI percentile.

<sup>^</sup> Adjusted for Age, Race, Sex, Baseline BMI, Parent BMI, PCP age, and Practice Effects (clustering)



**Table 3.**Year 2 adjusted BMI Percentile Change by MI Dose Received BMI<sup>2</sup>

Study Group	N	Mean BMI Percentile Change <sup>^</sup> (SE)
Group 1	149	1.7 <sup>1,2</sup> (.94)
Group 2 PCP only; Low < 3 MI	23	3.2 (2.1)
Group 2 PCP only; High >= 3 MI	112	4.2 (1.0)
Group 3 PCP + RD; Low < 8 MI	104	4.6 <sup>2</sup> (1.0)
Group 3 PCP + RD; High >= 8 MI	37	5.5 <sup>1</sup> (1.6)

<sup>^</sup> Adjusted for Age, Race, Sex, Baseline BMI, Parent Gender, Household Income, Parent BMI, and Practice Effects (clustering) SE- Standard Error; Groups with common superscript significantly differ; p < .05

**Table 4:**Year 2 adjusted Behavioral Outcomes<sup>^</sup>

Study Group	Fruit and Vegetables Serving p/day (SE)	Physical Activity Hours p/day (SE)	Sweetened Beverages Serving p/day (SE)	Screen Time Hours p/day (SE)
Group 1	3.8 <sup>1</sup> (.12)	2.1 (.05)	1.3 (.11)	2.5 <sup>1</sup> (.10)
Group 2	4.1 (.14)	1.9 (.06)	1.3 (.11)	2.4 <sup>2</sup> (.11)
Group 3	4.3 <sup>1</sup> (.13)	2.1 (.06)	1.0 (.12)	2.2 <sup>1,2</sup> (.10)

Groups with common superscript significantly differ;  $p < .05$ <sup>^</sup> Adjusted means for age, race, sex, baseline value, and practice effects (clustering) SE- Standard Error

**Table 5:**Odds of a Parental Reported A Grade<sup>^</sup> at 2-year Follow-up for Target Health Behaviors

Study Group	Fruits Intake	Vegetable Intake	Physical Activity	Sweetened Beverages	Eating Out	Screen Time	TV Time Snacks
Group 1 (ref)	1.0	1.0	1.0	1.0	1.0	1.0	1.0
Group 2	1.7	1.1	.71	1.2	1.1	.86	1.1
Group 3	2.1 <sup>1</sup>	1.7	2.0 <sup>1</sup>	1.4	1.8	1.4	1.8

Superscript indicates odds of parent reporting an “A” grade versus other grade are significantly greater than Group 1

<sup>^</sup> Adjusted for age, race, sex, baseline value, and practice effects (clustering)

**Table 6.**Parent process data collected at end of BMI<sup>2</sup> trial (n=280)

Survey Item	Not at all	A little /somewhat	A lot
The <b>doctor</b> asked my opinion about things	1%	24%	75%
The <b>RD</b> asked my opinion about things	5%	39%	56%
The <b>doctor</b> gave me choices about what to do	0%	22%	78%
The <b>RD</b> gave me choices about what to do	5%	35%	60%
The <b>doctor</b> listened to me	1%	6%	93%
The <b>RD</b> listened to me	3%	21%	76%
The <b>doctor</b> rushed me through the interview	92%	5%	3%
The <b>RD</b> rushed me through the interview	88%	7%	5%
The <b>doctor</b> was supportive and encouraging	1%	8%	91%
The <b>RD</b> was supportive and encouraging	5%	19%	76%
The <b>doctor</b> and I discussed values that are important to me	0%	21%	79%
The <b>RD</b> and I discussed values that are important to me	6%	28%	66%

**Table 7.**

Classification results for counselor Reflections and Questions using an SVM classifier

Feature group	Reflections				Questions			
	Accuracy	Precision	Recall	F1 score	Accuracy	Precision	Recall	F1 score
Baseline	64%	0	0	0	66%	0	0	0
N-grams	83%	78%	80%	79%	54%	38%	35%	36%
Semantic information	72%	67%	51%	58%	NA	NA	NA	NA
Similarity	63%	58%	27%	37%	NA	NA	NA	NA
Deep syntax	87%	82%	86%	84%	91%	90%	88%	87%