Statistical Analysis Plan
for
A Cluster Randomized Trial of the H2GO! Program

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9-22-2020, Version 1.0

Statistical Analysis Plan

Expected Enrollment

For our cluster-randomized controlled trial, we expect to enroll 10 Boys and Girls Club (BGC) sites with an average of 45-parent child pairs per site for a total of 450 child participants and 450 parent participants.

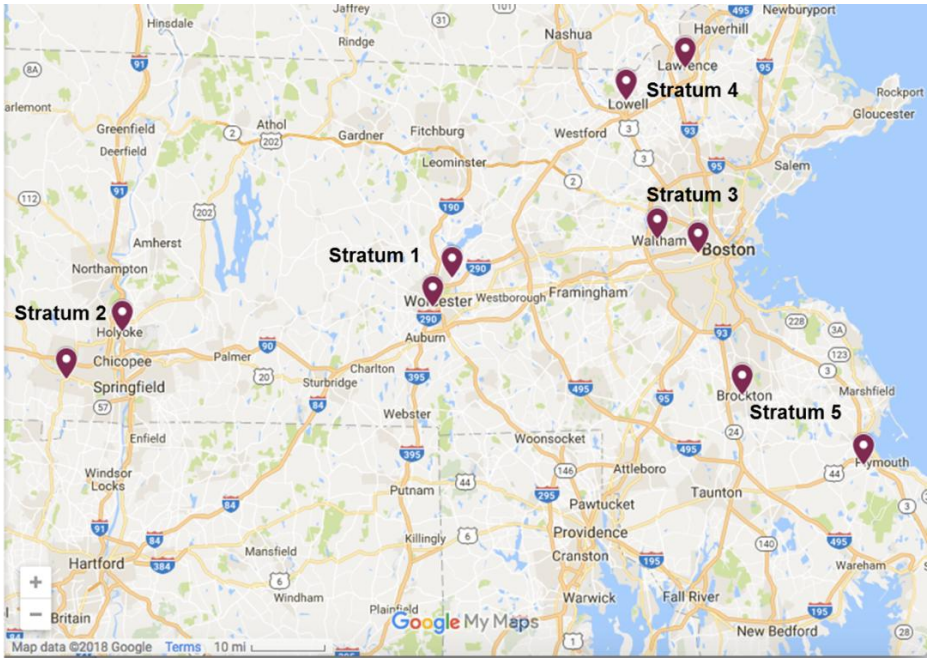
Effect Size and Power

We have based our sample size calculations on the primary hypothesis that child participants in intervention sites will have reduced body mass index z scores (zBMI) than child participants in comparison sites from baseline to 12 months. Our preliminary study showed an effect size of 0.22 units over 6 months. We will power our analysis to detect a minimum effect size of 0.1 units over 12 months (a conservative approach considering possible attenuation of effects over the doubling of study time period) and conservatively anticipate a 0.15 SD in both groups. A 0.1 effect size is reasonable for populations inclusive of healthy weight children; of studies targeting school-aged children including those of healthy weight, randomized SSB interventions have yielded 0.0-0.13 unit differences in zBMI over 12-18 months,[60,61] and childhood obesity prevention interventions have yielded 0.10-0.16 unit differences in zBMI over 12 months.[30,105] Based on previous studies,[106-108] we expect the intra-class correlation coefficient (ICC) to be between 0.01 and 0.05. We assume an ICC=0.05. With α=0.05, and a more conservative 75% retention rate, we can detect $\geq$ 0.1 unit difference in zBMI with over 80% power and 0.2 unit difference with over 90% power by enrolling a total of 450 parent-child pair participants (average of 45 parent-child per site). Based on our pilot study, recruitment and retention of this sample size is feasible. The anticipated level of adherence to the intervention is 90% and is based on our pilot study fidelity data. Participants with incomplete follow-up can be included in analyses, which are valid under a missing at random (MAR) assumption. We will assess the likelihood of nonignorable missing data using a pattern mixture model.

Cluster-randomization

Randomization will be conducted at the site level (cluster randomization) with 10 BGC sites. Geographic location will be used as a stratification variable as follows (see Figure 1): *Stratum 1:* Worcester (Main South and Great Brook Valley), *Stratum 2:* Holyoke and Westfield, *Stratum 3:* Waltham and Alston, *Stratum 4:* Lowell and Lawrence, *Stratum 5:* Brockton and Plymouth. Sites within each stratum are spaced > 5 miles apart to minimize contamination. One site within each stratum will be randomly assigned to the intervention and the other to a wait-list, attention-control condition (standard BGC programming). The randomization will be conducted by the project statistician using computer-generated random numbers. While the chances of baseline imbalances are higher in a cluster randomized design, we opted to use a priori stratified sampling scheme to increase balance of BGC characteristics between study arms, reflect the hierarchical structure of design in the analytic plan, and include a representative sample of BGCs to increase generalizability.

Figure 1. Stratification of Boys and Girls Clubs (BGCs) by Geographic Location



Statistical Methods

Aim 1. To test our primary hypothesis that children in the intervention sites will have decreased zBMI compared to children in comparison sites, we propose to apply generalized linear mixed models using zBMI as the main outcome. The hierarchical structure of the data (repeated measures on youth nested within BGC sites) will be modeled by including participant- and site-level random intercepts. A more complex covariance structure for repeated measures over time on participants (e.g. unstructured covariance) will be incorporated into the analysis if necessary. The main predictors of the model include study condition (intervention vs. control), all time points (baseline, 2 months, 6 months, and 12 months), and the interaction term between study condition and time points. Intervention effects will be evaluated over the entire study period by testing the interaction term of time and study condition, and by specifically comparing change from baseline to 12 months using a statistical contrast. We will also compare changes from baseline to earlier time points using this approach. Covariates hypothesized to be associated with child BMI (e.g., gender, race, other dietary intake, physical activity, screen time) will be examined for balance between groups and incorporated into multivariable analyses if imbalances occur with a $p<0.1$ level of significance.

Potential moderating effects of gender, age, and race/ethnicity on intervention effects will be examined via a three-way interaction with the moderator, the study condition indicator and time. A significant interaction term signals possible moderating effects. In such cases, we will analyze and report intervention effects by appropriate subgroups (e.g., males vs. females). Participants with incomplete follow-up can be included in analyses, which are valid under a missing at random (MAR) assumption. We will assess the likelihood of nonignorable missing data using a pattern mixture model. All analyses will be performed using SAS v9.4 with $p<0.05$ considered statistically significant.

Aim 2. To test our secondary hypothesis that children in intervention sites will demonstrate reduced mean SSB intake and increased mean water intake than children in control sites from baseline to 12 months, we propose to compare child SSB and water intake using linear mixed models described in Aim 1. Predictors of the models include study condition indicator and its interaction term with time point. Methods for dealing with the hierarchical structure of the data and hypothesis testing are similar to those for Aim 1. Comparisons of changes from baseline to earlier time points (2 months and 6 months) will also utilize this approach.

Aim 3. For our mediation hypothesis, we will follow the framework of Baron and Kenney.[128] To examine the impact of including youth empowerment in the primary models on estimating change in child BMI z scores (primary outcomes) and child SSB and water intake (secondary outcomes), we will first examine the effect of the intervention on youth empowerment using the linear mixed model approach described above by testing whether the pattern of change in youth empowerment over time differs by study condition via a statistical interaction. Next, we will examine the effect of youth empowerment on primary and secondary outcomes by incorporating an empowerment by time interaction, i.e. testing whether patterns of change over time in outcomes depend on level of empowerment. Finally, we will incorporate both interaction terms (study condition by time and empowerment by time) to determine whether the intervention effect is partially or fully mediated by empowerment. We will examine empowerment as a mediator regardless of statistical significance of the intervention effect, recognizing that this is not necessary for mediation to have occurred.[132] While there are other attractive approaches to mediation analysis, such as the regression approaches of VanderWeele,[133] these methods have not yet been adapted for use in clustered longitudinal study designs. Our planned mediation analysis is appropriate for our study design and allows us to assess partial or complete mediation by examining intervention effect. Note that under the absence of treatment-mediator interaction the causal inference approaches collapse to the Baron and Kenny approach.[134]