



# Relationship between teacher fidelity to an early childhood obesity prevention program and the Child care center nutrition and physical activity environment

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## ABSTRACT

**Background:** Child care centers (CCC) can be strategic settings to establish healthy lifestyle behaviors through obesity prevention programs. Fidelity to the implementation of such programs is a vital evaluation component, but is often not measured. This study assessed CCC teacher fidelity to the implementation of “Healthy Caregivers, Healthy Children (HC2)”, a CCC-based obesity prevention intervention.

**Methods:** CCCs serving low-resource, ethnically diverse families with  $\geq 50$  children ages 2-to-5 years old that were randomized to the HC2 intervention and that had teacher fidelity data collected ( $n = 9$  CCC) were included in this analysis. The Environment and Policy Assessment and Observation (EPAO) tool assessed the CCC nutrition and physical activity (PA) environment at the beginning/end of the school year. Fidelity assessments were conducted in CCCs randomized to HC2 in Spring 2016 ( $n = 33$  teachers) and 2017 ( $n = 39$  teachers) by a trained observer. The relationship between teacher fidelity and EPAO was assessed via mixed models.

**Results:** For every-one unit rise in teacher fidelity, EPAO nutrition increased 0.055 points ( $p = .006$ ). No significant relationship was shown between teacher fidelity and EPAO PA score ( $p = .14$ ).

**Conclusion:** Teacher fidelity to obesity prevention program implementation may support a healthy CCC obesity prevention and nutrition environment but might require continued support for all components.

## 1. Introduction

Over the last four decades childhood obesity has increased in the United States (US) and worldwide. (Von Hippel and Nahhas, 2013) The 2015–16 National Health and Nutrition Examination Survey population level data shows the prevalence of obesity in preschool children ages 2-to-5 years old is 13.9 %. (Health E-Stats, 2020) Obesity in the pediatric population remains a topic of concern among healthcare providers and policy makers as it predisposes children to various chronic disease risk factors including elevated insulin, blood pressure and lipids. (Kyrou et al., 2018) Also, previous studies have shown that children with unhealthy weight in early childhood are at higher risk for having obesity as an adolescent and an adult, (Singh et al., 2008) thereby making early prevention efforts imperative.

Indeed, the World Health Organization states that the introduction of healthy lifestyle initiatives have the potential to provide sustainable

outcomes among children in these early, formative years of life. (World Health Organization, 2020) Moreover, the U.S. Census Bureau reported the average preschool-age child spends 33 h per week (Laughlin, 2011) in a CCC setting, while others report children from low-income families consume 50 % to 100 % of their recommended dietary allowances in CCC care. (Fox et al., 2007) Also, the Federal Interagency Forum on Child and Family Statistics reports that 70 % of preschool-aged children with employed mothers were enrolled in a CCC as the primary care arrangement. (Federal Interagency Forum on Child and Family Statistics, 2019) These statistics support childcare centers (CCC) as a potential idyllic setting to introduce obesity prevention initiatives (Natale et al., 2013).

A recent meta-analysis of 58 CCC-based obesity prevention studies showed that early childhood obesity interventions are effective in reducing body mass index (BMI) in children of preschool age. Specifically, compared to control children, those receiving an intervention had

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a lower BMI at the end of the intervention ( $g = 0.10$ , 95 % CI = 0.02–0.18;  $k = 55$ ) and at the last.

follow-up ( $g = 0.17$ , 95 % CI = 0.04–0.30;  $k = 14$ ; range = 18–143 weeks). (Scott-Sheldon et al., 2020) Other systematic reviews have reported that multi-component, multi-level early childhood education interventions that include parental engagement result in positive anthropometric outcomes (Ward et al., 2017) and that the majority of interventions had the intended effect on the target: obesity 48 % ( $n = 14$ ), physical activity 73 % ( $n = 30$ ), diet 87 % ( $n = 39$ ), and screen time 63 % ( $n = 5$ ). (Sisson et al., 2016) While the evidence of CCC-based obesity prevention efforts is encouraging, to date little attention has been paid to teacher fidelity to such programs. (Schaap et al., 2018) Measuring teacher fidelity to these efforts may guide program developers, CCC directors, administrators, and support staff in decision making for further improvements as such efforts can highlight barriers and facilitators to sustainability. (Schaap et al., 2018; U.S. Department of Health and Human Services Centers for Disease Control and Prevention, 2011) Here we examined teacher fidelity to “Healthy Caregivers-Healthy Children (HC2)”, a cluster randomized controlled trial conducted to test the effectiveness of a childhood obesity prevention program from 2015 to 2018 in 24 low-income, ethnically diverse CCCs. Specifically, this analysis examined the (1) correlation between CCC teachers fidelity to HC2 implementation protocols and the CCC nutrition and PA environment, measured as the Environment and Policy Assessment and Observation (EPAO) tool; and (2) association between longitudinal change in teacher fidelity and CCC EPAO nutrition and PA scores over 1 year (from Spring 2016 to Spring 2017). It was hypothesized that teacher fidelity to HC2 implementation would be positively correlated with EPAO nutrition and PA scores.

## 2. Methods

### 2.1. Participants

The healthy caregivers–healthy children (HC2) randomized controlled trial (trial #02697565) was conducted over 2 school years (2015–2017) in 24 CCC (12 intervention, 12 control) serving low-income, ethnically diverse families in Miami-Dade County, Florida. Both arms are followed and/or receive treatment for two school years (approximately 9 months each). Longitudinal assessment of teacher fidelity to HC2 implementation was conducted at two timepoints in the intervention CCCs only; at the end of school year 1 in Spring 2016 ( $n = 8$  centers) and at the end of school year 2 in Spring 2017 ( $n = 9$  centers). Not all CCCs had data available for analysis due to scheduling conflicts with the centers. The University Institutional Review Board approved this study protocol, and each teacher provided informed consent to participate in the study (Clinical Trial # NCT01722032).

### 2.2. HC2 program description

An in-depth description of the Healthy Caregivers Healthy Children (HC2) protocol is available elsewhere (Natale et al., 2013; Messiah et al., 2016). In brief, 24 CCCs serving low resource families with  $\geq 50$  2-to-5-year olds attending were randomized to either intervention ( $n = 12$ ) or control ( $n = 12$ ) in South Florida. The HC2 intervention arm CCCs received implementation of a daily curriculum for (1) teachers/parents; (2) children; (3) snack, beverage, physical activity, and screen time policies; and (4) technical assistance with menu modifications. Control arm schools received an attention control safety curriculum. Because the train-the-trainer method involves a cascading training structure HC2 was designed to gradually reduce the direct role of the university team and give front line center staff the needed skill set to sustain HC2. As such, Year 2 of the HC2 study differed from year 1 regarding training dosage, which changed from monthly in year 1 to quarterly booster sessions in year 2.

### 2.3. Procedures

Trained graduate-level trained research staff ( $N = 3$ ) assessed teacher fidelity, who conducted a one full day observation in the teacher’s classroom during the end of school year 1 (Spring 2016) and year 2 (Spring 2017). One full day is defined as opening to closing and thus included two meals (breakfast and lunch) and two snacks (morning and afternoon) as well as morning and afternoon physical activities. Each teacher was observed in their classroom and CCC environment (e.g., during snacks, breakfast, lunch, outdoor and indoor activities). A different pair of trained program staff performed EPAO data collection in a single day observation (a different day than the fidelity assessment, and again included the entire day from opening to closing) at the beginning and end of each school year, i.e., pre-and-post-HC2 toolkit implementation in all study years (Messiah et al., 2016). The baseline data collection for EPAO commenced in August 2015 at the beginning of the school year at the center level. EPAO data utilized in the current study correspond to the same timepoints as teacher fidelity assessment, i.e., Spring 2016 and Spring 2017. Interrater reliability assessment showed 80 % agreement on each teacher fidelity checklist item and EPAO nutrition and PA assessment.

### 2.4. Measures

#### 2.4.1. Teacher Intake Survey

The teacher intake survey collected basic demographic information of all the teachers at the intervention CCC at baseline (August 2015) including age, sex, race/ethnicity, education level, and years of service. This data was only collected at baseline with the exception of age and years of service.

#### 2.4.2. Teacher Fidelity Assessment

A total of 45 teachers consented to participate in the study. In the spring 2016, 33 teachers were assessed. In the spring 2017, 27 of those teachers continued and were assessed as well as an additional 12 new teachers. Thus, the total teachers in spring 2017 = 39. (Fig. 1).

A total of 20 items were included in this assessment that took place during a single day sitting/observation by a trained research staff. The core design of this tool, designed specifically for the HC2 trial, aimed to assess teacher’s adherence to the policies of HC2, i.e. snack, beverage, physical activity and screen time, and if the teacher implemented the essential knowledge and skills from the HC2 intervention. The details of the full 20 item assessment are presented in Table 1. Items 1–19 were measured on a Likert scale as one of the following – strongly disagree, disagree, did not observe, neither agree nor disagree, agree, and strongly agree. Item 20 ‘overall observer opinion’ marked as poor, average, good, and excellent.

For the analysis, Likert scale options for the items 1–16 and item 19 were recoded and given a numerical value – 2, – 1, 0, 1, 2, and 3, respectively, i.e. ‘strongly disagree = – 2’, ‘disagree = – 1’, ‘did not observe = 0’, ‘neither agree nor disagree = 1’, ‘agree = 2’, and ‘strongly agree = 3’. For Item 17 (teacher drank unhealthy drinks, i.e. sweetened beverage in front of children) and Item 18 (teacher used screens in front of children) a negative response was considered affirmative of fidelity to HC2 implementation, hence, recoded as ‘strongly agree = – 2’, ‘agree = – 1’, ‘did not observe = 0’, ‘neither agree nor disagree = 1’, ‘disagree = 2’, and ‘strongly disagree = 3’. For item 20, ‘poor = 0’, ‘average = 1’, ‘good = 2’, and ‘excellent = 3’. The teacher fidelity score was calculated as the summative total of the 20 items for each sample teacher with a maximum score possible of 60, and minimum of –38.

#### 2.4.3. Environment and Policy Assessment and Observation (EPAO)

The EPAO tool is validated to evaluate the CCC nutrition and physical activity environment and was initially developed for the Nutrition and Physical Activity Self-Assessment for Child Care (NAP SACC) evaluation. (Ward et al., 2008; Mirzaei, 2022) The EPAO activity was

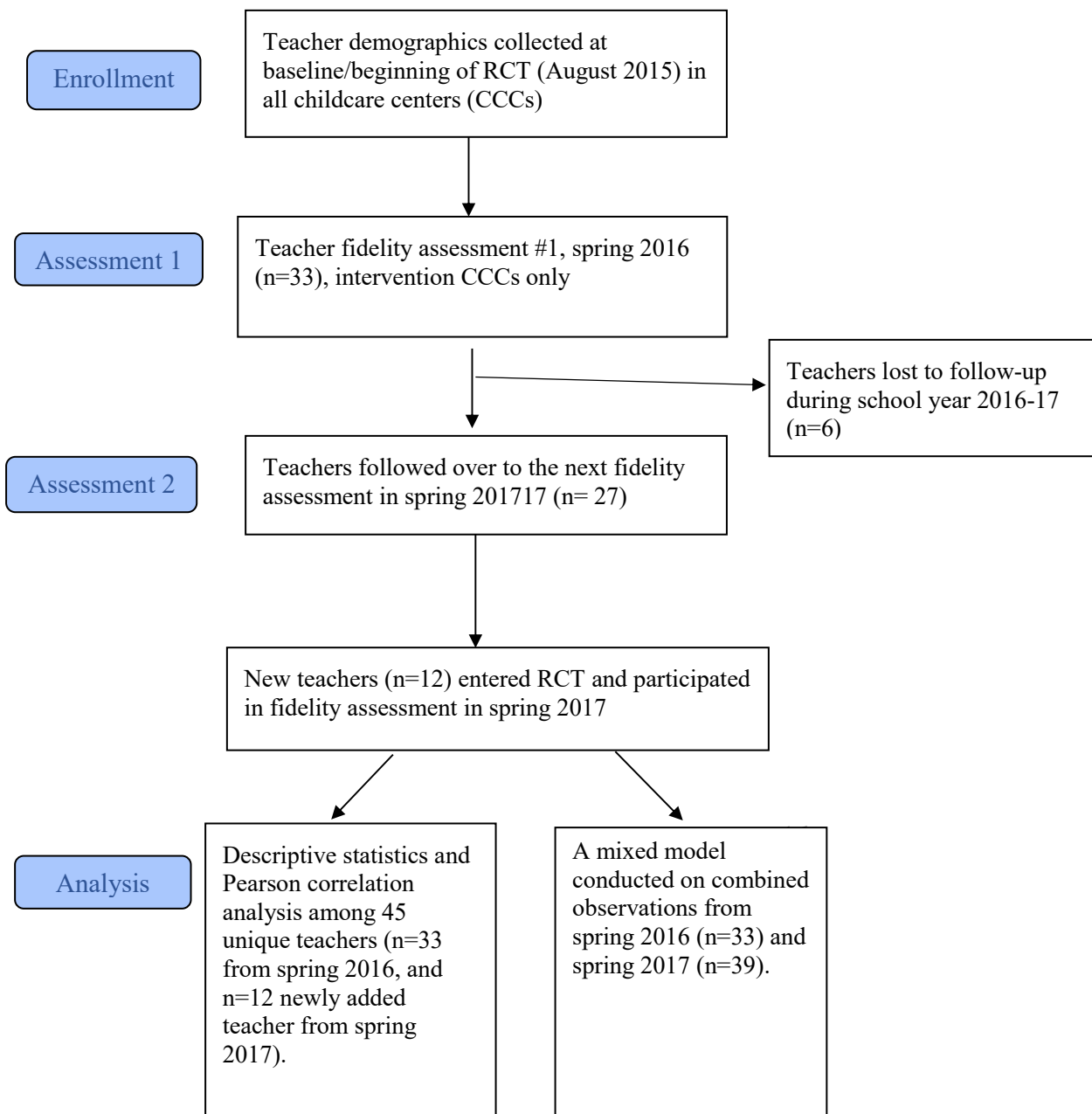


Fig. 1. Teacher Fidelity Assessment Flow Diagram for Healthy Caregivers-Healthy Children (HC2) at Intervention Centers.

conducted over one school day, incorporating direct observation of the nutrition and physical environment and a documented review of activities at the CCC level (versus individual classroom). (Ward et al., 2008) HC2 nutrition and PA policies were in accordance with EPAO, hence EPAO score was the primary outcome measure to assess the improvement in the participating CCC nutrition and PA environment. The EPAO data was collected by trained research staff members at the beginning and end of each school year, starting in August 2015 and commencing in Spring 2017. The EPAO total nutrition score was based on a total sum of 8 components that included centers consumption of fruits and vegetables, whole grains and low-fat meats, high sugar/high fat foods, beverages, nutrition environment, staff behaviors-nutrition, nutrition training and education, and nutrition policy. EPAO total physical activity (PA) score was based on a sum of 8 components that included active opportunities, sedentary opportunities, sedentary environment, portable play environment, fixed play environment, staff behaviors-physical activity, physical activity training and education, and physical activity policy,

detailed scoring guidelines mentioned elsewhere. (Ward et al., 2008) In sum, the possible scores for each EPAO nutrition and EPAO PA ranges from 0 to 20. Further, EPAO scores were modified to account for missing values; i.e. of the eight subscales of EPAO nutrition and EPAO PA, if a component was missing a value, the middle possible value was assigned to it, and then EPAO total nutrition and EPAO total PA score was calculated for the center. **Assigning the middle value is similar to mean imputation which results in unbiased estimates when missing is not informative** (Mirzaei et al., 2022). A total of 16 cells, that is, <3 % of the EPAO nutrition scores were imputed while 29 cells, that is, approximately 5 % of the EPAO PA were missing. Every teacher was given the same EPAO score in accordance with their CCC at that time period.

### 2.5. Data analysis

Baseline characteristics were evaluated for n = 45 unique

**Table 1**  
Items Observed by Trained Program Staff to Assess Teachers' Fidelity to the HC2 Implementation\*.

1. The teacher had all the materials necessary to conduct the activity.
2. The lesson's objective is clear to the observer.
3. The teacher presented the core components of the lesson to the children.
4. The teacher followed the steps of the activity accurately.
5. The teacher was knowledgeable about the HC2 curriculum.
6. The teacher showed enthusiasm with children when delivering lesson (e.g. positive energy, eye contact, motivating, etc.).
7. The teacher asked discussion questions during and/or after the activity.
8. As needed, the teacher adapted the lesson to meet the needs of individual children (e.g., helping children with fine motor difficulties).
9. The My Body Poster was visible to children in the classroom.
10. The MyPlate Poster was visible to children in the classroom.
11. Handouts from the HC2 curriculum were visible to children in the classroom (e.g. yoga poses, fruit/vegetables/protein handouts).
12. The classroom displayed artwork/activities made by children that promote physical activity (e.g. pictures of children outside, animal dice).
13. The classroom displayed artwork/activities made by children that promote healthy eating (e.g. pictures of children, pea plant activity, fruit bowl).
14. Physical Activity: The teacher engaged in physical activity with the children (inside and outside the classroom).
15. Snack: The teacher ate healthy foods in front of the children during snack time (i.e. no soda, fast food, or chips).
16. Beverage: Teachers drank water in front of the children.
17. Beverage: Teachers drank unhealthy beverages in front of children (e.g., sports drinks, vitamin water, punch, soda).
18. Screen Time: Teachers used screens (e.g., phones, tablets) in front of the children.
19. Overall: The teacher was actively participating with the children instead of telling them what to do.
20. Observer's opinion of overall teacher rating <sup>†</sup> .

HC2, Healthy Caregivers Healthy Children  
 \*Items 1 – 19 Scaled on a Likert Scale as – strongly disagree, disagree, did not observe, neither agree nor disagree, agree, strongly agree.  
<sup>†</sup> Item 20 scaled as poor, average, good and excellent.

participants (Table 2). Means and standard deviations were generated for all continuous data, and frequencies for categorical data. Pearson's correlation coefficients were calculated to measure the strength of the association between the teacher fidelity scores and the EPAO nutrition and EPAO PA scores. Via a hierarchical linear model, (Ward et al., 2008) mixed model analysis (PROC MIXED) assessed the impact of total teacher fidelity score on EPAO scores, and if the relationship varied over the time (Edwards, 2000), or from Spring 2016 to Spring 2017 (end of the school year in both years). A mixed-effect linear regression model with teacher ID within CCC as the random effect was fitted to assess the relationship between the exposure teacher fidelity score and outcomes EPAO scores and was controlled for age, years of service (a continuous variable), and race/ethnicity. **The within and between the correlation of the teacher was taken into consideration since they were**

**Table 2**  
Descriptive Statistics of total participating HC2 Teachers, N = 45.

	N (%) or mean (SD)
Age (years) (mean, SD)	43.6 (11.05)
Gender	
Male	1 (2.2)
Female	44 (97.8)
Education Level	
Less than high school	4 (9.3)
High school diploma/GED	5 (11.6)
Some college	9 (20.9)
Associate's degree	8 (18.6)
Bachelor's degree	15 (34.9)
Graduate degree	2 (4.6)
Race/ Ethnicity	
Hispanic	31 (72.1)
Non-Hispanic White	1 (2.3)
Non-Hispanic Black	6 (13.9)
Others	5 (11.6)
Years in service (mean, SD)	21.5 (13.8)

SD, Standard Deviation.

**analyzed as the experimental unit.** Teachers within CCC with teachers as the experimental unit Time was treated as a continuous variable, i.e., time for 33 teachers' observations in spring 2016 was coded as '1', and time for 39 teachers' observations in spring 2017 was coded as '2'. Race/ethnicity was a categorical variable with levels created for Hispanic, Non-Hispanic white, Non-Hispanic black, and Others. Since only one male teacher was included in the sample, gender was highly skewed. Hence, gender was excluded from the mixed model analysis to have a parsimonious model. Education level was dropped as it was highly correlated with the race/ethnicity (Likelihood Ratio Chi square = 0.6023). The level of significance for the resulting values was set at  $\alpha = 0.05$ , i.e. a p-value < 0.05. All statistical analyses were performed in SAS v 9.4 (SAS Institute Inc, Cary North Carolina).

### 3. Results

Almost all ( $\approx 98\%$ ) teachers were female, and the mean age of the study sample was 43.6 years (SD  $\pm 11.05$ ). Over a third (39.5%) of the teachers had a bachelor's degree or higher, whereas 20.9% had high school education or less. The majority of teachers self-identified as Hispanic (72.1%). The average years of service by a participating teacher was 21.5 years ( $\pm 13.8$ ) (Table 2).

#### 3.1. Correlation between teacher fidelity score and EPAO scores

##### 3.1.1. Teacher Fidelity Score

The teacher fidelity score ranged from a minimum score of -7 to a maximum score of 54. The mean of the teacher fidelity score across the sample of 45 teachers was 26.58 ( $\pm 22.27$ ) (Table 3).

##### 3.1.2. EPAO Scores

Mean EPAO total nutrition score across intervention CCCs was 13.7 ( $\pm 1.6$ ) ranging from 11.7 to 16.9; and mean EPAO total physical activity (PA) score was 10.4 ( $\pm 2.2$ ) ranging from 6.6 to 15.4 (Table 3).

A significant correlation of medium strength between teacher fidelity score and EPAO total nutrition score ( $r = 0.44$ ,  $p = .0028$ ) was found. No significant correlation was found between EPAO total PA score and teacher fidelity score ( $r = -0.024$ ,  $p = .87$ ) (Table 3).

#### 3.2. Impact on EPAO scores in relation to teacher Fidelity, time and both

The HC2 study was a hierarchical data, where teachers were nested within the centers. The mixed model (MM) is the best approach for analysis since it models both the fixed and random effects while accounting for between and within groups differences. (McCullagh and Nelder, 1989) In MM, the inferences are made on the fixed or main effect and are similar to a regression model. However, in the presence of an interaction term in the MM, like the one used in our analysis, the literature suggests interpreting each main effect with the interaction term. Further, if a statistically significant interaction occurs, i.e.,  $p < 0.05$ , the final inference should be based on the interaction term coefficient. (Crossa et al., 2015) The interaction term (teacher fidelity \* time) assessed an overall effect of how teacher's fidelity impacted outcome EPAO scores when time continuously moved from spring 2016 (end of

**Table 3**  
Correlation between Teacher Fidelity Score of the Unique Teacher Participants (n = 45) and EPAO Nutrition Score, and EPAO Physical Activity Score.

	Mean (SD)	1	2	3
1. EPAO Nutrition Score	13.7 (1.6)	1	-	-
2. EPAO Physical Activity Score	10.36 (2.2)	-	1	-
3. Teacher Fidelity Score	25.8 (22.3)	<b>0.445*</b>	-0.024	1

EPAO, Environment and Policy Assessment and Observation. SD, standard deviation.

\* Pearson correlation coefficient is significant at  $p < .01$  level (2-tailed).



year 1) to Spring 2017 (end of year 2).

Regression analysis showed the main effect of CCCs' teachers fidelity ( $\beta = 0.055$ , 95 % CI 0.018 – 0.09,  $p = .006$ ) and time ( $\beta = 1.89$ , 95 % CI 1.1 – 2.6,  $p < .0001$ ) on the EPAO nutrition scores outcome was positive and statistically significant. However, in an additional regression analysis, the interaction between the CCCs teacher fidelity score and time in the model negatively impacted the revised EPAO nutrition scores ( $\beta = -0.02$ ; 95 % CI – 0.043– 0.0005) and was statistically significant ( $p = 0.046$ ). (Table 4).

In the MM of teachers fidelity score and the EPAO PA score, the effect of interaction term (teachers' fidelity\*time) ( $\beta = -0.02$ ; 95 % CI – 0.06–0.017;  $p = .27$ ), and the individual impact of teacher fidelity score ( $\beta = 0.045$ , 95 % CI – 0.016–0.1;  $p = .14$ ) was statistically insignificant. However, time ( $\beta = 3.57$ , 95 % CI – 2.27–4.87;  $p < .0001$ ) demonstrated a positive rise in the revised EPAO PA scores from year 1 to year 2. (Table 5).

#### 4. Discussion

Results showed that CCC teacher fidelity to HC2, an early childhood obesity prevention intervention was significantly correlated with the CCC nutrition environment, but not with the physical activity environment. Although higher teacher fidelity to HC2 implementation was associated with an improvement in the CCC nutrition environment at the end of year 1, a robust relationship could not be established over the period of one year from spring 2016 to spring 2017 (interaction term). This finding implies a potential contextual factor, which negatively impacted the results over time. In year 1 of the study (August 2015-July 2016), trained staff provided monthly technical assistance to the teachers to implement the HC2 curriculum, whereas in year two (August 2016-July 2017) it was reduced to quarterly, suggesting that CCC teachers need monthly assistance to implement HC2 correctly. Overall, these findings hence suggest the need for increased, and sustained support to teacher to implement early childhood obesity programs in the CCC setting in the form of monthly technical assistance, especially if they include PA components.

The relationship between teacher fidelity and CCC nutritional environment highlights the important role of teachers as delivery agents for obesity prevention programs that include a dietary intake component. (Ward et al., 2008) The positive correlation with medium strength of association between teacher fidelity and CCC nutritional environment that was found here was in contrast to a previously published process evaluation of a school-based childhood obesity prevention program that found no significant association between teacher's fidelity and program outcomes. (Hunter et al., 2001) Additionally, a study by Little et al reported improved relationship between teacher fidelity and student outcome when the program was tailored based on feedback from preceding events. (Burgermaster et al., 2017) Specifically, the program was tailored based on teacher feedback following implementation in the

**Table 4**  
Relationship between Teacher Fidelity Score and the Outcome EPAO Total Nutrition Score<sup>†</sup> for n = 72 Observations (in Spring 2016n = 33, and in Spring 2017n = 39).

Exposure Variable	$\beta$ estimate (SE)	p - value	Lower 95 % CI	Upper 95 % CI
Teacher fidelity score	0.055 (0.018)	0.006**	0.018	0.09
Time	1.89 (0.37)	<0.0001***	1.1	2.6
Teacher fidelity score *	- 0.02 (0.01)	0.046*	- 0.043	- 0.0005
Time (interaction term)				

\*  $p < .05$ , \*\*  $p < .01$ , \*\*\*  $p < .001$  (2-tailed). SE, standard error. CI, Confidence Interval.

<sup>†</sup> Mixed model regression with control for age, race/ethnicity and total years in service.

**Table 5**

Relationship between Teacher Fidelity Score and the Outcome EPAO Total PA Score<sup>†</sup> for n = 72 Observations (in Spring 2016n = 33, and in Spring 2017n = 39).

Exposure Variable	$\beta$ estimate (SE)	p - value	Lower 95 % CI	Upper 95 % CI
Teacher fidelity score	0.045 (0.029)	0.14	- 0.016	0.1
Time	3.57 (0.62)	<0.0001*	2.27	4.87
Teacher fidelity score *	- 0.02 (0.018)	0.27	- 0.057	0.017
Time (interaction term)				

\*  $p < .001$  (2-tailed). SE, standard error. CI, Confidence Interval.

<sup>†</sup> Mixed model regression with control for age, race/ethnicity and total years in service.

previous school year (fourth to fifth grade), and changes may have enhanced teacher understanding and improved their ability to align program delivery with the intended curriculum. This finding reinforces the need for ongoing training and support so that teacher fidelity aligns with correct program implementation.

In spite of initial teacher fidelity to HC2 program nutritional components, our models, and interaction term in particular showed that the effect of correct implementation of HC2 diminished over a year. This may be attributed to presence of potential external contextual factors and cannot be linked to the efficiency of an evidence-based teaching practice, (Little et al., 2015) which was role-modeling in HC2 (Stains and Vickrey, 2017). HC2 included monthly technical support that was delivered to the CCC teachers on monthly; and 4 booster trainings in year 2 which may have resulted in the diminished fidelity findings. Also, a reactivity effect of being observed for an entire school day may have made some teachers strongly adherent while some may have been more poorly adherent to HC2 protocols. (Kim et al., 2020) Given the small sample size; decline of impact over time could be due to loss to follow up of six strongly adherent participants from Spring 2016 to 2017. In addition, twelve new teachers in Spring 2017 who had only had booster sessions and not monthly training exposure in study year 1 might have affected the quality of class management and the delivery of the HC2 intervention curriculum. (Breitenstein et al., 2010; Torres et al., 2020) Indeed; other studies have called attention to the importance of addressing contextual factors in relation to teacher fidelity to intervention implementation as crucial to the quality of service delivery and program effectiveness (Mihalic et al., 2008).

Our analyses showed no significant relationship between teacher fidelity and EPAO PA scores, which remained unchanged on conducting regression testing with potential confounders. Previous studies report that 3–5 years old children enrolled at preschool receive a decreased level of moderate and vigorous physical activity with the maximum time being spent in sedentary activity. (Vanderkruik et al., 2017; Brown et al., 2009) Also, child-initiated activities were strongly associated with PA versus those that were teacher led. (Vanderkruik et al., 2017) Another study reported that teacher barriers to adherence to PA included personal health of the teacher and personal view of suitable weather to play (Pate et al., 2004 Nov) Since this program was implemented in a South Florida where both mornings and afternoons are often extremely hot, and from August-November can also be rainy, weather may have been a barrier to CCC-implementation of the “Did you observe any outdoor active play” EPAO PA component. Other possible explanations for this finding may be driven by the fact that the majority of EPAO PA items are focused on the CCC environment and availability of specific equipment and resources including balls, parachutes, push/pull equipment, riding, rocking/twisting toys, and twirling play equipment, as well as a basketball hoop, pool, slides, tricycle track, tunnels and outdoor running spaces, which is largely out of the control of teachers, and thus could negatively impact overall fidelity outcomes. It is also important to note that all of these centers serve low resource families and many have limited space to accommodate all of the pieces of equipment listed in the

EPAO to support physical activity. Nevertheless, as stated previously, it will be important with future efforts to provide consistent technical and other support to CCC teachers, as well as to CCC directors and staff to promote consistent physical activity and to decrease sedentary behaviors.

The use of a mixed model method or mixed-effect regression model (MRM) for evaluating these repeated measures on various participants over time should be noted as a strength of the analysis reported here. This accounts for the randomness which arises due to more than one source of random variability in the data (Copeland et al., 2012). Mixed model approaches allow both within-subject and across-subject variability over time in a longitudinal study to be assessed. In addition to individual change over time, MRM also accounts for missing or unequal data, hence giving more power to the analysis (Verbeke and Molenberghs, 2000).

## 5. Limitations

Some study limitations should be noted. Even though this was a longitudinal study, only two time points were included in this analysis which reduces precision; also, the sample size of the participants was relatively small to produce a robust inference. Also, there may have been a selection bias given that not all CCCs and teachers participated in the fidelity measures. In other words, CCCs and teachers who did not participate may have been less likely to practice fidelity with HC2. However, the characteristics of those CCCs that did not participate did not differ from those that did; all serve ethnically diverse, low resource families in the same county and are similar in size. In addition, the CCC directors who are responsible for decision-making and policy implementation should be included in future fidelity assessments to meaningfully interpret the results.

## 6. Conclusion

Teachers fidelity assessment is a crucial step in the process evaluation of childhood obesity prevention programs such as HC2 in the CCC setting but to date has been underutilized. The results from this study showed that CCC teacher fidelity to an early childhood obesity prevention intervention was significantly correlated with the CCC nutrition environment, but not with the physical activity environment. These findings suggest that CCC teachers may need consistent assistance and support to implement obesity prevention programs correctly, especially if they include PA components. Measuring teacher fidelity to these efforts may guide future obesity prevention program developers and CCC leadership in decision making for further improvements and can highlight barriers and facilitators to sustainability.

## 7. Human subjects approval statement

This study was approved by University of Miami Institutional Review Board (Clinical Trial # NCT01722032) for studies involving human participants.

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## CRedit authorship contribution statement

**Priyanka Rana:** Conceptualization, Methodology, Software, Writing – original draft. **Folefac D. Atem:** Data curation, Methodology, Writing – original draft, Writing – review & editing. **Cynthia Lebron:** Conceptualization, Formal analysis, Writing – original draft, Writing – review & editing. **M. Sunil Mathew:** Software, Data curation, Validation, Writing

– review & editing. **Ruby A. Natale:** Supervision, Funding acquisition, Investigation, Methodology, Project administration, Writing – review & editing. **Sarah E. Messiah:** Conceptualization, Data curation, Funding acquisition, Investigation, Methodology, Project administration, Resources, Supervision, Writing – original draft, Writing – review & editing.

## Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

## Data availability

Data will be made available on request.

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