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The Healthy Kids & Families study: Outcomes of a 24-month childhood obesity prevention intervention

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ABSTRACT

Socioeconomically disadvantaged children experience a high burden of obesity but few interventions address obesity prevention in this population subgroup. The Healthy Kids & Families study tested the effect of a parent-focused community health worker (CHW)-delivered lifestyle intervention to prevent childhood obesity. Participants were child-parent/guardian (Kindergarten to 6th grade at baseline) dyads (n = 247) recruited through schools located in socioeconomically disadvantaged neighborhoods in Worcester, MA, USA. Using a quasi-experimental design, the study tested the impact of Healthy Kids & Families, a theory-based, low-intensity, parent-focused, CHW-delivered intervention to improve children's weight, healthy eating and physical activity. The attention-control comparison condition was a positive parenting intervention. The primary outcome was change in child body mass index (BMI) z-score at 24 months. Secondary outcomes included number of positive child and parent changes in selected diet and physical activity behaviors targeted by the intervention and change in parent BMI. Outcomes were assessed following the intent-to-treat principle and using multivariable generalized linear mixed models. Compared to the attention-control comparison condition, the Healthy Kids & Families intervention led to a greater reduction in children's BMI z-score ($\beta = -0.17$, 95 %CI: −1.92 to −0.36; $p = 0.057$) and a greater number of positive behavior changes among children ($\beta = 0.57$, 95 %CI: 0.08–1.06; $p = 0.02$) at 24 months. There was no significant change in parent outcomes. The Healthy Kids & Families intervention shows promise for obesity prevention among children in socioeconomically disadvantaged communities.

1. Introduction

One in five children in the United States (US) ages 6–11 have obesity, with higher rates among racial/ethnic minority and socioeconomically disadvantaged children (Ogden et al., 2018). Given the increased health, developmental and psychosocial risks associated with childhood obesity, (Cote et al., 2013; Lloyd et al., 2012; Mohanan et al., 2014; Janssen et al., 2004; Latner and Stunkard, 2003; Schwimmer et al., 2003; Lobstein et al., 2004; Singh et al., 2008; Freedman et al., 2005; Gordon-Larsen et al., 2010; Jensen et al., 2013) prevention remains a public healthy priority in the US (Brown et al., 2019; Ng et al., 2014; Koplan et al., 2005). The American Academy of Pediatrics, (American Academy of Pediatrics et al., 2008; Davis et al., 2007; American Academy of Pediatrics, 2015; Centers for Disease Control and Prevention, 2018a) and the American Heart Association (Daniels et al., 2009) have issued evidence-based recommendations for childhood obesity prevention through lifestyle change, such as reducing sugar sweetened beverages, high calorie snacks and sedentary screen time use, and increasing consumption of fruits and vegetables and physical activity (Janssen and Leblanc, 2010; Tremblay et al., 2011; Malik et al., 2006; Larson and Story, 2013). However, adherence to these recommendations remains low, especially among youth from socioeconomically disadvantaged backgrounds (Haughton et al., 2016).

Four large clinical trials have tested interventions to prevent obesity

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among school-age children (Fulkerson et al., 2015; Hull et al., 2018; Klesges et al., 2010; Elder et al., 2014). The tested interventions ranged in duration from 10 months to 2 years, all were relatively intensive including a combination of group sessions and phone contacts, and all targeted a parent and at least one child via separate or joint sessions. All trials failed to observe significant changes in child BMI z-scores, and poor intervention participation was cited as an important challenge to intervention impact. Thus, there is a need to examine the potential impact of less burdensome interventions, especially among socioeconomically disadvantaged families who often experience multiple and competing time demands (Schor et al., 2003; Lindsay et al., 2018; Lange et al., 2017; Perzow et al., 2018) while suffering the greatest disparities

Behavioral targets	• Reduction of sugar-sweetened beverages • Reduction of high calorie snacks • Reduction of screen time • Increase in fruits and vegetables • Increase in physical activity
Intervention algorithm	5As: • Agenda for the session • Assess parent's concerns, motivation, family diet/physical activity/sedentary behaviors, change attempts facilitators and barriers • Advise on benefits of healthy diet, physical activity and weight • Assist with: o Information gaps (BMI, intervention behavior change targets) o Family-centered goal-setting and problem-solving for managing child obesogenic behaviors, including plans for changes in the home environment and use of community resources • Arrange follow up, including time and format of next contact
Format	• Quarterly 20-min contacts with the parent, alternating individual in-person (home or other preferred location) and telephone • Follow up letter after each contact with summary of goals set and related print materials • Quarterly newsletter • Community navigation events • Facebook messages
Intervention coach	Trained community health worker (bilingual (English/Spanish) and bicultural)

Fig. 1. Overview of the Healthy Kids & Families Intervention.

in childhood obesity.

This study tested the effectiveness of Healthy Kids & Families, a theory-driven, low-intensity, parent-focused community health worker (CHW)-delivered obesity prevention intervention aimed to prevent childhood obesity and foster improvements in diet and physical activity among socioeconomically disadvantaged children and their parents.

2. Methods

Using a quasi-experimental design, the study compared the Healthy Kids & Families intervention to an attention-control comparison condition (detailed methods described elsewhere (Borg et al., 2019). Nine public elementary schools (Kindergarten to 6th grade) located in racial/ethnically diverse low-income communities of Worcester, MA (USA) were invited and agreed to partner with the study. The school was the unit of intervention allocation (matched by demographic profile and geographic location), with four schools being allocated to the intervention and five to the attention control comparison condition. The Institutional Review Board of the University of Massachusetts Medical School and the Worcester Public School Research Committee approved the study. The trial was recorded in ClinicalTrials.gov (NCT03028233).

3. Study sample

Child-parent dyads (one dyad per household) were recruited between June 2015 and May 2017. Study participants were child-parent/guardian dyads (child-parent dyads) recruited from these schools via a letter and a response card sent by the school principal to families in the children's backpacks. Parents received $10 for mailing back the response card with information to be contacted for eligibility determination (i.e., child attending a participating school, access to a telephone, English or Spanish speaking, no plans to move away during study period) by a study staff. The parent that completed the response card along with his or her child whose birthday was closest were selected for participating. Parents provided written consent, children aged 6–9 provided verbal assent, and children of ages 10 and older provided written assent.

4. Study conditions

4.1. Healthy Kids & Families intervention condition

Summarized in Fig. 1 below (and previously described in greater detail) (Borg et al., 2019) Healthy Kids & Families was a low-intensity (2 in-person and 2 telephone contacts per year), parent-focused intervention for improving child weight, healthy eating and physical activity, and delivered by a bilingual (English-Spanish) CHW. Guided by social cognitive theory and social ecological principles, (Bandura, 1997; Stokols, 1996; Sallis et al., 2008) and delivered using a 5As counseling framework and motivational interviewing principles, (Whitlock et al., 2002; Carroll et al., 2012; Spahn et al., 2010; Miller and Rollnick, 2013) it targeted the child's social and physical home environment by intervening with parental weight-related knowledge, beliefs, and skills for managing child obesogenic behaviors; and addressed families' needs for community resources supportive of the targeted behavioral changes. The intervention targets included consumption of healthy low-calorie snacks, reduction of fast food, reduction of sugar sweetened beverages, engagement in physical activity at least 60 min/day and reduction of screen time to <2 h/day. Messages related to these targets were summarized under the acronym "SUPER": Snack Smart, Unplug and Play, Prepare and Plan, Energize with Exercise, and Rethink your Drink. Parents were encouraged to set realistic goals for behavior change of the entire family and to problem-solve strategies to achieve their goal, including modifications to the food and activity environment in the home; neighborhood factors that could be challenges to a healthier lifestyle, and encouraged to utilize, existing community resources supportive of their healthy lifestyle goals.

4.2. Attention control comparison condition

The positive parenting comparison condition focused on reinforcing parental skills to facilitate child development of positive relationships, attitudes and behaviors and used a similar format as the experimental condition (Borg et al., 2019). The intervention format was identical to the format of the intervention condition.

4.3. Measures

The primary outcome was change in child BMI z-score at 24 months. Secondary outcomes included child and parent changes in dietary and physical activity behaviors and change in parent BMI at 24 months. Surveys were verbally administered. Parents of younger children assisted them or reported on their behalf, as needed. Data were collected in community settings from December 2015 to April 2019 and analyzed in 2019–2020. The assessment window for the final outcome extended for six months after the last intervention session.

Child BMI z-score and parent/guardian BMI. Weight was measured with a digital Tanita BWB- 800 scale and height was measured with a SECA 213 stadiometer (Centers for Disease Control and Prevention, 2021; Centers for Disease Control and Prevention, 2020). Child BMI z-score was calculated according to the CDC's US children growth chart(Centers for Disease Control and Prevention, 2018c) Parent/guardian BMI was calculated from weight and height measures (kg/m^2) (Centers for Disease Control and Prevention, 2018b) .

Behavioral (secondary) outcomes. Ten discrete behaviors (seven diet and three physical activity/sedentary) were assessed with 32 items (Davison et al., 2015; Hedrick et al., 2010; Neuhouser et al., 2009; Kowalski et al., 1997) (adapted from previous surveys –see Supplemental Table 1) in both children and parents/guardians at baseline and 24 months. Positive changes in dietary behaviors reflect increased frequency of weekly consumption of water, fruit, vegetables and healthy snacks, and decreased weekly consumption of sugar-sweetened beverages, fast food, and unhealthy snacks. Positive changes in physical activity behaviors included increased weekly time in exercise and utilitarian walking (i.e., walking for the primary purpose of accomplishing errands or getting somewhere such as walking to a store/library, bus stop, or school or after-school program, not primarily for exercise or leisure (Hekler et al., 2012) and decreased time in sedentary activities. Given the family-centered nature of the intervention where families could select to focus on one or more behavior(s) of their choice, the total number of positive behavior changes was used to assess positive behavior changes.

Demographics. A baseline survey assessed child and parent age, sex, race/ethnicity; and parent/guardian marital status, education, employment status, household income, and language spoken at home. Changes in parent marital status, employment and household income were recorded in follow-up visits.

4.4. Statistical analysis

Data analyses followed the intent-to-treat principle. All enrolled participants were included in analysis with the intervention group assignment at baseline. Between intervention group differences in outcomes were assessed with and without adjustment for participant-level covariables. Baseline sociodemographic and behavioral characteristics of the groups were compared using either Chi-square test for categorical variables (baseline BMI category) or Wilcoxon rank sum tests for continuous variables (e.g., age and BMI). Intervention effects were defined as between intervention group differences in change from baseline to 24-month in specific outcomes, and were assessed using generalized linear mixed models, with and without adjustments for age, gender, race/ethnicity, parental education and baseline BMI z score.

Participants from the same school were treated as a cluster. Autocorrelations among measurements from the same person were modeled using unstructured covariance to obtain robust estimates. Lost to follow-up was treated as missing data that are potentially informative. We applied inverse probability weighting methods to reduce potential follow-up (or dropout) bias by modeling the probabilities of lost to follow up at specific time points based on data at baseline and previous time points. This approach has been successfully applied in our previous randomized trial studies (Lemon et al., 2010; Lemon et al., 2014). All tests were two-sided at 0.05 significance level.

5. Results

In all, 247 child-parent dyads participated in the trial. Of those, 225 were still eligible at 24 months and were included in the analysis. Reasons for 24-month ineligibility included child no longer living with the parent (n = 6) or moving away (n = 16). The retention rate for eligible dyads was 74 %, with reasons for lost to follow up including contact information no longer valid (n = 23), calls not returned (n = 22) and refusal to continue participating (n = 13). Comparison of baseline characteristics of completers and dropouts showed that the parent age of dropouts was younger (34 vs 37) and a larger percentage of dropouts spoke English only at home (59 % vs 40 %). There was no significant difference in child demographics. The final analytic sample included 167 dyads.

Table 1 shows the sample baseline characteristics. There were no differences in the children demographics across conditions except for a small, but statistically significant, difference in average age (p = 0.05). Approximately 60% of the children were of Hispanic/Latino ethnicity. As for the parent/guardians, most were female but there were statistically significant differences in sex across conditions with greater representation of males in the comparison versus the intervention condition (p = 0.05). There also was a significant difference in marital status across conditions (p < 0.03). Slightly over half of parents/guardians reported Hispanic/Latino ethnicity, one-fifth had less than high-school education, over one-third were not employed, and slightly over half reported an annual household income of less than $20,000. Over half of the sample spoke a language other than or in addition to English in their home.

Session completion for each study condition was as follows: participants in the Healthy Kids & Families intervention condition completed an average of 1.60 (SD = 1.25) in-home sessions, 1.44 (SD = 1.26) telephone sessions and 3.03 (SD = 2.08) total sessions over the two years. A total of 17 parents in the intervention condition attended no sessions at all. In the attention control comparison condition participants completed an average of 1.50 (SD = 1.14) in-home sessions, 1.45 (SD = 1.42) telephone sessions and 2.95 (SD = 2.15) total sessions. A total of 22 parents in this control condition attended no sessions.

Table 2 shows crude and adjusted analysis for the primary outcome, namely difference in pre-post changes in child BMI z-score from baseline to 24 months between two intervention conditions, with and without adjustment for baseline covariates. Unadjusted results showed a greater 24-month reduction in BMI z-score among children in the intervention compared to the comparison condition (p = 0.01). However, this difference became marginally significant (p = 0.06) after adjustment for child age, gender and race/ethnicity and parental education (co-variates selected a priori). No changes in parent/guardian BMI were observed between the groups (data not shown).

Children in the intervention condition had a greater number of positive behavior changes at 24 months compared to children in the comparison condition in crude analysis (data not shown). This difference maintained statistical significance after adjustment for covariates (p = 0.02), shown in Table 3. There were no statistically significant changes for the individual diet or physical activity/sedentary behaviors assessed, although the intervention group had marginally significant reductions in weekly frequency of fast food consumption and increases

Table 1
Demographic Characteristics of Children and Parents/Guardians at Baseline.

	Intervention (n = 121) Mean (SD) or %	Attention Control (n = 126) Mean (SD) or %	P value
Child			
Age	8.61 (2.05)	8.06 (2.19)	0.05
Sex			0.84
Male	52.07	50.77	
Female	47.93	49.21	
Race/ethnicity			0.68
White non-Hispanic	16.53	13.60	
Black non-Hispanic	13.22	20.00	
Asian non-Hispanic	2.48	2.40	
Multi-race/other non-Hispanic	5.78	4.00	
Hispanic/Latino	61.98	60.00	
Grade (at baseline)			0.26
Kindergarten	10.74	23.01	
Grade 1	16.53	18.25	
Grade 2	13.22	12.70	
Grade 3	19.83	15.87	
Grade 4	16.53	11.90	
Grade 5	10.74	10.32	
Grade 6	12.40	7.94	
BMI Z-Score	1.00 (1.23)	0.78 (1.16)	0.16
BMI category			0.06
Normal (<85th Percentile for BMI)	46.55	58.40	
Overweight (85th – 95th Percentile for BMI)	15.52	17.60	
Obese (≥95th Percentile for BMI)	37.93	24.00	
Parent			
Age	35.93 (6.95)	36.59 (7.78)	0.48
Sex			0.05
Male	4.96	11.90	
Female	95.04	88.10	
Race/ethnicity			0.19
White non-Hispanic	22.31	22.22	
Black non-Hispanic	13.22	21.43	
Asian non-Hispanic	2.48	2.38	
Other non-Hispanic	7.44	1.58	
Hispanic/Latino	54.55	52.38	
Marital status			0.03
Single	28.93	41.13	
Married/living as married	53.72	45.97	
Separated/divorced	17.36	10.48	
Widowed	0.00	2.42	
Education			0.22
<high school	17.36	20.63	
High school/GED	63.64	62.70	
>high school	19.00	16.67	
Employment			0.70
Employed	57.50	60.00	
Not employed	42.50	40.00	
Household income			0.70
< $20,000	53.33	57.26	
$20,000 – $50,000	36.67	35.48	
> $50,000	10.00	7.26	

(continued on next page)

Table 1 (*continued*)

	Intervention (n = 121) Mean (SD) or %	Attention Control (n = 126) Mean (SD) or %	P value
Child			
Language spoken at home			0.24
English only	48.74	43.55	
More English than another language	9.24	14.52	
Equally English and another language	9.24	16.13	
More another language than English	20.17	13.71	
Only another language	12.61	12.10	
BMI	32.03 (6.98)	31.77 (7.51)	0.74
BMI category			0.27
Normal (<25 kg/m2)	17.65	16.1	
Overweight (25–29.9 kg/m2)	24.37	33.90	
Obese (>30 kg/m2)	57.98	50.00	

in weekly frequency of fruit consumption at 24 months compared to the comparison group (p = 0.07). There were no significant differences in parent outcomes (Supplemental Table 2).

6. Discussion

The Healthy Kids & Families intervention showed promise for promoting lifestyle changes among diverse socioeconomically disadvantaged elementary school children. The observed change in children's post-intervention BMI z-scores, while marginally significant after adjusting for covariates, is consistent with the number of positive behavior changes observed in the intervention versus the comparison condition. Furthermore, the observed effect size for BMI z-scores in the intervention group (0.17) was slightly greater than the effect size observed in prior studies (0.098) (Wang et al., 2013). The study did not observe statistically significant behavior changes for individual diet or physical activity/sedentary behaviors assessed, a finding that can be explained by the tailoring of the intervention to the target population, including culture and language (i.e., delivery by a bicultural and bilingual community health worker, literacy-sensitive materials in English and Spanish), the intervention focus on parents setting behavioral goals based on their perceived priorities for their families (rather than given uniform intervention goals) and guidance for parents to leverage existing community resources for reaching their goals. Despite the less than ideal session completion, our study findings are encouraging given the few family-based models for targeting obesity prevention among school-age children and the limited or no impact of previous interventions on child weight or behaviors.

The existing literature on childhood obesity has largely focused on its treatment rather than prevention. Further, the few family-based studies of obesity prevention aimed at children of elementary school age have involved intensive interventions (i.e., multiple and lengthy in-person group sessions) and require participation of the children and the parents. One study (Fulkerson et al., 2015; Fulkerson et al., 2018) of English-speaking families of 8–12 year old children with BMI-for-age percentiles above the 50th percentile (n = 160) tested an intervention consisting of ten monthly in-person group sessions for families and five goal-setting calls with parents versus an attention-control comparison condition. Another trial focused on pre-school Hispanic children ages 5–7 years old and their families (child sex- and age-specific BMI ≥ 25th percentile or parent with BMI > 25; n = 272) (Hull et al., 2018) tested a year-long intervention involving eight 90-minute group family sessions followed by monthly contacts alternating a call from a lay health worker or a newsletter versus a comparison condition. Both studies reported changes in selected diet or physical activity behaviors (i.e., increased time in weekend physical activity, (Hull et al., 2018) reduction in sugar sweetened beverage intake) (Fulkerson et al., 2015; Fulkerson et al., 2018) at 6 and 12 months but changes were not sustained at longer term follow up (Fulkerson et al., 2015; Hull et al., 2018; Fulkerson et al., 2018) and the interventions had no impact on BMI z-scores.

Two earlier pilot studies tested intensive family-based obesity prevention interventions. The first one (Chen et al., 2010) included child-mother dyads targeting 8–10 year old English, Mandarin or Cantonese-speaking Chinese children (BMI percentile in the normal and overweight range; n = 67 dyads) through eight weekly group sessions for the children and two 2-hour group workshops for the mothers. At 8-month follow up, there were significant reductions in child BMI and fat intake and increases in fruit/vegetable consumption and physical activity, compared to a wait list control condition. However, results from this pilot are limited by the small sample size, high maternal level of education, the exclusion of non-Chinese participants, short follow up period, and differential attrition across study conditions (25 % vs 6 % for wait list vs intervention group). Another pilot study (Beech et al., 2003) that tested a child-targeted vs a parent-targeted version of a 12-week obesity prevention intervention showed a trend toward reduced BMI and a significant decrease in sugar-sweetened beverages in the parent-targeted intervention compared to a comparison condition among low-income African-American girls aged 8 to 10 years (age- and sex-specific BMI ≥ 25th percentile; n = 60). However, a larger trial (Klesges et al., 2010) that expanded the intervention (34-sessions over two years, with girls and parents in joint and separate sessions) vs a control condition, failed to show an intervention effect on child weight or physical activity outcomes, although it did find small, marginally significant improvements in water and sugar-sweetened beverages consumption and vegetable intake.

Another study (Elder et al., 2014) tested a 2-year intervention that promoted healthy eating and the use of a recreation center for physical activity, vs a control condition, among economically and culturally diverse families of 5–8 year old children (n = 541). The intervention included five group workshops, a 1-hour home visit, monthly (mailed) tip sheets, and two consultation calls after each tip sheet. Findings showed a significant post-intervention reduction in fat intake and sugary beverage consumption in favor of the intervention condition, but no effect on child BMI. The authors attributed limited findings to a low intervention dose, including poor participant engagement.

While marginally significant, our child BMI-z outcomes may reflect the enhancements of our intervention over those in previous studies. As

Table 2
Differences in change in child BMI Z-scores between the Healthy Kids & Families intervention condition and the attention control condition at 24 months (n = 225).

	Healthy Kids & Families mean (SD)	Attention control mean (SD)	Unadjusted difference in change from baseline	95 % CI	P-Value	Adjusted difference in change from baseline*	95 % CI	P-Value
Baseline	1.00 (1.23)	0.78 (1.16)	***	***	***	***	***	***
24 Month	0.83 (1.23)	0.83 (1.13)	−0.24	(-0.42, −0.05)	0.014	−0.17	(-0.36, 0.01)	0.059

* Adjusted for baseline age, sex, race/ethnicity and parent education and child BMI z score.

Table 3
Differences (Mean ± SE) in Pre-Post Child Behavior Changes in the Healthy Kids & Families Intervention versus the Control Condition: Adjusted 24-Month Results (N = 225).

	Healthy Kids & Families Intervention Condition				Positive Parenting Comparison Condition				Difference in pre-post change between conditions	p
	Baseline	24 Months	Difference	p	Baseline	24 Months	Difference	p		
Number of positive behavior changes		4.04 (0.18)				3.42 (0.17)			0.61 (0.25)	0.02
Servings of water (per week)	13.69 (0.63)	13.58 (0.77)	0.01 (0.68)	0.99	14.89 (0.62)	14.98 (0.73)	0.37 (0.65)	0.57	−0.36 (0.96)	0.71
Servings of sugar sweetened beverages (per week)	17.26 (1.17)	9.11 (1.1)	−7.75 (1.07)	<0.01	17.23 (1.15)	11.43 (1.05)	−5.44 (1.02)	<0.01	−2.32 (1.49)	0.12
Fast food (per week)	1.14 (0.15)	0.93 (0.2)	−0.26 (0.2)	0.18	1.3 (0.14)	1.47 (0.19)	0.23 (0.19)	0.21	−0.49 (0.27)	0.07
Servings of fruit (per week)	8.83 (0.54)	8.83 (0.59)	−0.06 (0.58)	0.91	9.51 (0.53)	7.51 (0.56)	−1.53 (0.55)	0.01	1.47 (0.81)	0.07
Servings of vegetables (per week)	6.19 (0.46)	6.18 (0.51)	−0.33 (0.48)	0.49	7.73 (0.45)	6.18 (0.48)	−0.93 (0.46)	0.04	0.6 (0.68)	0.38
Healthy snacks (per week)	5.57 (0.57)	6.69 (0.82)	−0.16 (0.8)	0.84	8.05 (0.56)	5.79 (0.78)	−1.43 (0.76)	0.06	1.27 (1.12)	0.26
Unhealthy snacks (per week)	13.68 (1.15)	8.91 (0.96)	−4.47 (0.94)	<0.01	12.41 (1.13)	7.43 (0.92)	−5.92 (0.89)	<0.01	1.45 (1.31)	0.27
Sedentary activity (hrs/week)	10.96 (1.05)	11.61 (1.46)	−0.22 (1.43)	0.88	10.34 (1.02)	13.25 (1.44)	1.68 (1.37)	0.22	−1.89 (2.01)	0.35
Utilitarian walking (hrs/week)	2.03 (0.29)	0.84 (0.23)	−0.81 (0.23)	<0.01	1.37 (0.28)	0.98 (0.22)	−0.53 (0.22)	0.01	−0.28 (0.32)	0.39
Exercise (hrs/week)	11.76 (1.21)	11.86 (1.42)	0.97 (1.47)	0.51	9.77 (1.15)	8.92 (1.39)	−1.48 (1.38)	0.28	2.45 (2.06)	0.23

Number of positive behavioral changes is defined as count of improved behaviors (e.g., reduced fast food intake, reduced sedentary behaviors, increased walking and exercise) among the 10 listed individual behaviors for each participant.
* Adjusted for baseline age, sex, race/ethnicity and parent education and baseline child BMI z- score.

recommended by leading experts, (Koplan et al., 2005; Strategic plan for NIH obesity research, 2004) our intervention was tailored to the cultural and literacy needs of diverse low-income families, including intervention delivery by a bilingual/bicultural CHW and a maximum of 8 intervention contacts over 2 years, in person or by phone, thus reducing parental burden associated with intensive interventions. The intervention length rather than session intensity may be key to meaningful change in outcomes. Additionally, while the intervention had clear behavioral targets, it was flexible and encouraged parents to set one realistic goal for their entire family rather than prescribing goals based on an intervention curriculum. Lastly, our intervention acknowledged the importance of community resources, such as local playgrounds, hiking trails and farmers markets, that these low-income families could use based on goals, needs and preferences. The above-described previous study (Elder et al., 2014) that promoted the use of a community resource (recreational center) was not tailored to the families and had limited use.

While the studies reviewed above target children and families together for obesity prevention, few studies of elementary school children target only the parent. Parent-focused obesity prevention interventions have shown effectiveness for reducing child BMI z scores among pre-school children (Knowlden and Sharma, 2012; Slusser et al., 2012; Barkin et al., 2012). Ours is one of few studies that have tested a parent-focused obesity prevention intervention in elementary school children, providing evidence of benefit in this age group.

Lastly, few childhood obesity prevention intervention studies have assessed parent outcomes. One prior study (Elder et al., 2014) that measured parental outcomes found no significant change in parent BMI. Our study confirms that a childhood obesity prevention intervention may not be of sufficient intensity to impact weight control among parents. Interventions that specifically target parent weight loss and energy balance may be needed to impact adult BMI.

Our study has several strengths. One strength is the low-intensity nature of the intervention, intentionally designed to have minimal time demands on overburdened parents (i.e., four in-person and four telephone contacts over 24 months). It also was intended to facilitate adoption of the intervention in resource-scarce settings. The intervention was tailored to cultural and literacy needs of families, including language (English/Spanish), low literacy materials and family-centered goals, and was delivered by a CHW. That such a low-touch intervention could achieve significant behavior and marginally significant weight change among this sample of diverse underserved children is perhaps the study's major strength. Another strength is the use of a comprehensive framework that considered multiple levels of influence (i.e., individual, the family physical and social home environment and neighborhood resources). Additionally, the use of the 5As algorithm sought to facilitate self-efficacy and behavior change skills of parents/guardians including personalized goal-setting, problem-solving and self-evaluation, important constructs in efficacious interventions. The 24-month follow up period also constitutes an important strength. Given the challenging nature of behavior change and weight loss, studies that examine the long-term impact of interventions are critical. Lastly, our study assessed outcomes on parents.

Despite these strengths, findings need to be interpreted in light of the following potential limitations. Quasi-experimental designs engender potential for unknown bias. The study attempted to reduce bias by allocating schools to intervention vs attention control condition paired on demographic characteristics and location. A second potential limitation is self-selection. Due to limitations of recruitment through schools, we were unable to determine the number of unique families reached through our recruitment effort (i.e., many families likely had more than one child at the schools). Families were recruited using an English/Spanish flyer sent home in their children's backpacks or at school events via study presentations, and thus we were unable to ascertain the recruitment rate. Another potential limitation is the self-report nature of our behavioral measures, which could include recall

and social desirability biases, (Althubaiti, 2016) and absence of psychometric data. We analyzed the simple count of positive changes in each of 10 dietary and physical activity behaviors. While we attempted to use accelerometry to assess physical activity, children commonly reported forgetting or refusing to wear the accelerometer. The study did not include more rigorous dietary measures such as 24-hr recalls or food frequency questionnaires due to limited data regarding validity of these measures among diverse children as well as practical reasons, including participant burden and concerns regarding study retention. To minimize bias, the study surveys were tested and revised for accuracy and understanding in both English and Spanish. Lastly, the study targeted families regardless of the weight status of their children (Rosal et al., 2003). Studies that target only overweight and obese children have been more effective than those targeting children with varying weight (Lavelle et al., 2012). However, the analysis of our study controlled for baseline BMI z-score of the children.

7. Conclusion

This low-intensity intervention led to a greater number of positive lifestyle behaviors and marginally significant reductions in BMI z-scores among children in the intervention compared to the control condition. Future directions should focus on measuring the cost-effectiveness of this and similar low-intensity obesity prevention interventions, due to their potential for implementation uptake in settings that serve low-income diverse communities who bear the greatest burden of childhood obesity (Sharifi et al., 2017).

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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Appendix A. Supplementary data

Supplementary data to this article can be found online at 10.1016/j.pmedr.2022.102086.

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