Research Brief

Impact of a Pilot School-Based Nutrition Intervention on Fruit and Vegetable Waste at School Lunches

Shreela Sharma, PhD, RD, LD[1]; Allison Marshall, MSSW, MPH[2]; Joanne Chow, MPH, RD[3]; Nalini Ranjit, PhD[2]; Gregory Bounds, MPH[3]; Katherine Hearne, MPH, RDN, LD[3]; Nan Cramer, RD, LD, SNS[4]; Amanda Oceguera, MS, RD, LD[4]; Alicia Farhat, MPH, RD, LD[5]; Christine Markham, PhD[3]

ABSTRACT

Objective: To determine the preliminary impact of the *Brighter Bites* nutrition intervention on decreasing fruit and vegetable (F&V) waste at school lunches among fourth- and fifth-grade children.

Method: This was a nonrandomized pre–post-controlled study in Houston and Dallas, TX. Two schools received the *Brighter Bites* intervention ($n = 76$), and 1 comparison school ($n = 39$), during the 2017-2018 school year. *Brighter Bites* is a 16-week school-based nutrition intervention providing weekly distribution of fresh F&V plus nutrition education. Main outcome measures were direct observation and weights to measure the number of F&V dishes selected at school lunches, amount of F&V wasted (gm), and related nutrient waste (4 time points/child). Mixed-effects linear regression analysis was used to determine change in F&V selection and waste over time.

Results: There was a significant decrease over time in proportion of F&V selected among those in the comparison school, but not the intervention schools ($P < .001$). Compared with children in the comparison group, those receiving *Brighter Bites* showed a significant decrease in the amount of F&V wasted at each meal ($P < .001$) and per item ($P < .05$) at the end of both 8 and 16 weeks of intervention. There were significant decreases in waste of energy (kcal); dietary fiber (gm); vitamins B_1, B_3, and B_6 (mg); total folate (μg); and B_{12} (μg) among those receiving *Brighter Bites* ($P < .05$).

Conclusions and Implications: Although absolute food or nutrient changes were small even when significant, programs such as *Brighter Bites* may contribute to a healthy intake. Future studies are warranted that include a larger sample size with a stringent, cluster-randomized control trial design and consideration for other covariates.

Key Words: child dietary intake, fruit and vegetable consumption, nutrient waste, plate waste, school lunch (*J Nutr Educ Behav.* 2019;000:1−9.)

Accepted August 8, 2019.

INTRODUCTION

Despite widespread national and international efforts to increase fruit and vegetable (F&V) consumption, children of all ages consume less F&V than recommended.[1,2] Children from lower income households are more likely to consume inadequate amounts of F&V compared with their higher-income counterparts,[3] which exacerbates health disparities through the life course. Sufficient F&V consumption is critical for healthy physical and psychosocial development and functioning, especially during periods of rapid growth in childhood and adolescence.[1] In children, higher F&V intake is associated with reduced risks for chronic diseases and risk factors such as obesity, diabetes, hypertension, high cholesterol, and nutrient

[1]Department of Epidemiology, Environmental Health, and Genetics, Michael and Susan Dell Center for Healthy Living, University of Texas School of Public Health, Houston, TX
[2]Michael and Susan Dell Center for Healthy Living, University of Texas School of Public Health in Austin, Austin, TX
[3]Department of Health Promotion Behavioral Sciences, University of Texas School of Public Health, Houston, TX
[4]Houston Independent School District Food Service Support Facility, Houston, TX
[5]Brighter Bites, Dallas, TX
This study was supported by Feeding Texas and the Texas Health and Human Services Commission. Feeding Texas and the Texas Health and Human Services Commission had no role in the design, analysis, or writing of this article.
Conflict of Interest Disclosure: The authors' conflict of interest disclosures can be found online with this article on www.jneb.org.
Address for correspondence: Shreela Sharma, PhD, RD, LD, Department of Epidemiology, Environmental Health, and Genetics, Michael and Susan Dell Center for Healthy Living, University of Texas School of Public Health, 1200 Pressler, RAS E603, Houston, TX 77030; E-mail: Shreela.V.Sharma@uth.tmc.edu

https://doi.org/10.1016/j.jneb.2019.08.002

deficiency.[4] Thus, promoting adequate intake of F&V among children, especially those from lower-income families, remains important.[3,4]

Over 30 million children rely on the *National School Lunch Program* (NSLP) for nutrient and energy intake during the school day, 20 million meals of which are free lunches to low-income children.[5] Students are required to select at least 1 fruit or vegetable per lunch meal under current regulations.[6] Unfortunately, previous plate waste studies demonstrated that children often do not consume the F&V selected from the lunch lines.[7−11] Plate waste during school lunch results in nutrient loss and unnecessary costs for schools and the NSLP.[8,10,12] *Brighter Bites* is an evidence-based school health promotion program that combines access to fresh F&V with nutrition education in school and at home to increase preference and intake of F&V among children. The current study tested the preliminary impact of *Brighter Bites* on (1) increasing the number of F&V dishes selected by children at school lunch, (2) decreasing the amount of F&V wasted during school lunch by weight and percentage (proportion of F&V wasted), and (3) decreasing F&V-related nutrient waste per lunch meal among elementary schoolchildren in Houston and Dallas, TX.

METHODS

Plate Waste Study Design

A nonrandomized pre−post-controlled trial design was employed for this study. Trained data collectors measured participating students' school lunch in the cafeteria at 4 1-week time points per child (Monday through Friday) during the 2017−2018 school year. A convenience sample of 3 schools participated in the study: 2 schools receiving the *Brighter Bites* program and 1 comparison school (not participating in *Brighter Bites*). At each time point, data were collected every day of the week (Monday through Friday). The *Brighter Bites* program is implemented over 16 weeks in the school year: 8 weeks in the fall semester and 8 in the spring, respectively. The 4 time points of data collection included the start of the school year before the beginning of *Brighter Bites* programming (baseline, wave 1), the midpoint of the program (end of 8 weeks in the fall, wave 2), before the beginning of the spring programming (wave 3), and the end of the 16 weeks of the *Brighter Bites* program (end of spring, wave 4). All fourth- and fifth-grade children in participating intervention schools were exposed to *Brighter Bites*, but only those who consented to participate in the study were measured. This study was approved by the University of Texas Health Science Center Committee for the Protection of Human Subjects.

Description of *Brighter Bites* Intervention

Brighter Bites is an evidence-based program[13] currently being disseminated nationwide through the Brighter Bites 501c3 nonprofit organization. A detailed description of the program is available elsewhere;[13] briefly, *Brighter Bites* is a 16-week school-based nutrition program grounded in Social Cognitive Theory constructs.[14] It consists of 3 main components: (1) weekly distributions of 50 servings of fresh donated F&V sourced from local food banks sent home with parents; (2) nutrition education, which includes the evidence-based *Coordinated Approach to Child Health* program in schools,[15,16] and parent education through bilingual nutrition handbooks and recipe cards; and (3) weekly recipe demonstrations at produce pickup time. Results of *Brighter Bites* evaluation demonstrated significant improvements in the intake of F&V among participating children and parents and improvements in the home nutrition environment.[13]

Recruitment and Participants

A convenience sample of 3 schools from 2 public school districts, 1 in Dallas, TX (district A) and another in Houston, TX (district B), was recruited to participate in the study. The schools were selected based on comparable racial and ethnic composition and the percentage of the student population eligible for the free or reduced-priced lunch program. Two elementary schools (1 in district A and 1 in district B) received *Brighter Bites* programming for the first time in the 2017−2018 school year; concurrently, the comparison school (in district B) was not receiving *Brighter Bites* and had never participated in it. Inclusion criteria for students included (1) being enrolled in *Brighter Bites* in the 2017−2018 school year for the first time (for intervention schools), (2) participating in the NSLP at the school, and (3) being enrolled in fourth or fifth grade in the 2017−2018 school year.

A total of 115 students were recruited and provided consent at the 3 schools (intervention school 1: n = 44; intervention school 2: n = 32; comparison school: n = 39). Two classrooms per grade were targeted for recruitment. Recruitment strategies consisted of presentation to school leadership and a parent invitation letter sent home for participation in the study. Of those in the participating grades, recruitment rates were 19.1%, 17.5%, and 39% in intervention schools 1 and 2 and the comparison school, respectively. Written informed consent was obtained from parents, and verbal assent obtained from children. At each time point, all children were measured for 5 days (the entire school week). Children who had <3 days of school lunch measurements at baseline were excluded from subsequent measurements. Finally, parent−child attendance to *Brighter Bites* distributions was obtained from *Brighter Bites*.

Data Collection Measures

A total of 15 data collectors, who were university graduate students, were trained by study investigators to conduct plate waste measures for the study. Before lunch, cafeteria staff provided data collectors with samples of all available choices of F&V options for that day. Across all 3 schools, 30 minutes was allocated for the lunch period. For each day of measurement, before the lunch period, trained data collectors recorded the type and number of F&V items offered, as indicated in production records provided by the school food and nutrition service staff, obtained 3 sample portions of each selection, and averaged the weights for each offering to generate standard weights. Across all schools, children chose F&V items from individual containers preserved by cafeteria staff. Before the lunch period, on each day of measurement, data collectors also provided tags with identifier numbers to participating children in their respective classrooms. Children wore these tags throughout the lunch period, and as they came through the lunch line with their trays after having selected foods, their trays were labeled with same identifier numbers. During lunch, data collectors recorded the type and number of F&V items selected by each participating child. After lunch, data collectors calculated the amount consumed by the student by weighing the total amount of each F&V food item wasted on participating students' plates using Schuler Scientific digital scales (SSP-1502, Englewood, CO). The F&V were weighed to the nearest 0.01 g. Interrater reliability was high (100% agreement) and an average weight difference of 0.012 g was found between raters ($r = .99$). Prior field-based studies showed that mobile electronic data systems have greater accuracy compared with secondary manual data entry.[17] Hence, for this study, a mobile data collection application in AppSheet (version 10.0, AppSheet, Inc, Seattle, WA, 2017) was developed and used in real time by trained data collectors to record all F&V selections and the amount of F&V waste data electronically.

Data Analysis

Descriptive statistics including means, SDs, and frequency distributions were computed at baseline. One-way ANOVA was used to assess for baseline differences in F&V waste among the 3 schools. All plate waste data and recipes for the F&V provided by school districts were entered into Nutrition Data System for Research software (Nutrition Data System for Research, University of Minnesota, Minneapolis, MN, 2016). For foods such as whole fruit (eg, whole bananas, whole uncut apples) or unopened packaged fruits or vegetables (eg, fruit cups), if the entire serving of fruit or vegetable was unconsumed, it was assumed that its weight was equal to that of the standardized sample plate. Plate waste percentage was calculated using the equation: ([1− weight of food remaining ÷ weight of standardized sample plate] × 100). Nutrient loss estimations for each specific nutrient were calculated using plate waste percentage and were adjusted to the standardized sample serving size. Mixed-effects linear regression models were used with group × time interaction terms to test for between-group changes over time. Children were tracked individually; analysis was at the child level. Plate waste measures were clustered within the child, and change in F&V plate waste measures and related nutrients wasted at the child level were assessed over time.[18,19] Although a cluster analysis adjusting for school as a random effect would have been the preferred analysis technique, given the small sample size at the school level, this was not performed; instead, school was adjusted for as a covariate in the analysis. All analyses were performed using Stata software (version 14.2 (StataCorp, College Station, TX, 2016). The level of significance was defined as $P < .05$. Goodness of fit tests were used to determine model fit.

RESULTS

All 3 participating schools had ≥90% of children participating in the free and reduced-price lunch program, which indicated that a majority of the children were from low-income families. At the school level, on average, 77.3% and 13.7% of children in the intervention schools and 81.5% and 12.6% of those in the comparison school were Hispanic or African American, respectively. The overall retention rate of participating children in the study was 79% (data not shown). After the initial measurement week (wave 1, baseline), 24 students were removed who did not meet the initial requirement of ≤3 school lunch measurements owing to absences or home lunches. Retention rates at waves 2, 3, and 4 were 84.1% for the intervention school 1 and 81.3% at intervention school 2. Furthermore, overall attendance at *Brighter Bites* weekly produce distributions was 64% (77% attendance rate in intervention school 1 and 50% in intervention school 2).

Table 1 shows the baseline descriptive statistics for F&V plate waste measurements, overall and stratified by schools and school districts. Overall, on average, 4.7 ± 1.51 unique varieties of F&V were available to children at the school lunches each day. Of these, each day, children chose an average of 1.2 ± 0.6 varieties and tried 0.9 ± 0.7 different F&V. Stratified analysis shows significant differences in the variety of F&V offered, selected, and tried among the 3 schools ($P < .001$).

At baseline, children wasted an average 59.5% of the F&V that they chose for school lunch. At baseline, although there were significant differences among schools for the average amount of F&V selected ($P < .001$) and the amount of F&V wasted ($P < .001$), there were no significant differences among schools in the average proportion of F&V wasted ($P = .91$). Table 1 also shows the baseline descriptive statistics for the percent F&V wasted stratified by various foods. The F&V most wasted were legumes and deep yellow and dark green leafy vegetables, whereas the least wasted foods were baked par-fried potatoes; 9% to 45% of foods were 100% wasted (ie, uneaten).

Table 2 shows the results of mixed-effects linear regression analysis. Whereas there was no change among those in the intervention group, there was a significant decrease in the proportion of F&V dishes selected by children in the comparison group at all waves of measurement ($P < .001$). Results also showed that, measured against those in the comparison school, at the end of the intervention (wave 4), children in the intervention schools had a significant decrease in the amount of F&V wasted at each meal ($\beta = -32.06$; 95% confidence interval, −48.9 to −15.2; $P < .001$) and per item ($\beta = -28.03$; 95% confidence interval, −39.7 to −18.4; $P < .001$). Total amount of energy regarding kcal, carbohydrate (gm), and protein (gm) wasted also decreased significantly among those participating in *Brighter Bites* measured against those in the comparison school at the end of 8

Table 1. Baseline Data on F&V Selection and Waste at School Lunches, *Brighter Bites* Plate Waste Study, 2017–2018

Variable	Average F&V[a] Items Available	Average F&V[a] Items Selected	Average F&V[a] Items Tried	Percentage wasted ([B / A] × 100)	100% Wasted
Overall (for all schools)	4.7 ± 1.5	1.2 ± 0.6	0.9 ± 0.7		
Intervention school 1	6.1 ± 1.1	1.0 ± 0.6	0.8 ± 0.7		
Intervention school 2	4.4 ± 0.8	1.3 ± 0.5	1.0 ± 0.6		
Control school	3.2 ± 0.4	1.4 ± 0.5	1.0 ± 0.7		
P[a]	<.001[b]	<.001[b]	.01[b]		
	Average F&V Amount Selected (g) (A)	**Average F&V Amount Wasted (g) (B)**	**Average Amount Consumed (g) (A − B)**		
Overall (for all schools)	103.2 ± 87.7	82.5 ± 68.7	55.1 ± 54.7	59.5 ± 35.5	15.0
Intervention school 1	143. 9 ± 105.1	101.0 ± 84.0	64.3 ± 65.9	59.5 ± 33.7	15.0
Intervention school 2	91.9 ± 64.5	71.5 ± 53.9	47.7 ± 44.0	60.5 ± 37.1	16.0
Control school	72.8 ± 67.9	67.9 ± 50.4	49.7 ± 44.9	58.5 ± 36.5	14.0
P[a]	<.001[b]	<.001[b]	.01[b]	.91	.90
Stratified by type of fruit and vegetable					
Citrus fruit	88.4 ± 9.7	52.0 ± 32.8	37.8 ± 33.9	58.5	20
Fruit (excluding citrus)	99.4 ± 27.2	56.4 ± 40.4	43.5 ± 35.3	55.2	27
Avocados and similar (Includes avocado in guacamole)	90.7 ± 0.0	83.1 ± 6.1	7.7 ± 6.1	91.6	14
Dark green vegetables (eg, broccoli, collards, romaine, spinach)	63.0 ± 16.9	43.2 ± 25.9	19.5 ± 16.3	64.8	18
Deep yellow vegetables (eg, carrots, winter squash, sweet potatoes, pumpkin)	77.7 ± 11.4	60.8 ± 17.1	16.0 ± 12.8	78.8	34
Tomato	74.0 ± 16.1	50.5 ± 28.6	23.2 ± 20.6	66.2	12
White potatoes	203.8 ± 57.0	110.6 ± 73.1	96.0 ± 85.2	58.0	13
Baked par-fried potatoes	70.1 ± 9.00	32.2 ± 28.8	39.4 ± 24.8	43.3	9
Other starchy vegetables[d]	137.9 ± 81.3	87.9 ± 68.3	71.4 ± 76.4	58.7	23
Legumes (cooked dried beans)	102.2 ± 10.4	78.8 ± 21.8	19.7 ± 25.3	81.2	45
Other vegetables[d]	53.1 ± 27.6	35.4 ± 33.1	19.0 ± 23.4	59.9	33

F&V indicates fruits and vegetables.

[a]Mean differences were analyzed by 1-way ANOVA; [b]Significance at $P < .05$; [c]Includes vegetables in salads, soups, stews, stir-fry, and similar mixed dishes (eg, corn, immature lima beans, lentil sprouts, peas); [d]Includes vegetables in salads, soups, stews, stir-fry, and similar mixed dishes (eg, beets, cabbage, mung bean sprouts, summer squash).

Notes: Data are shown as n ± SD. Study population was fourth- to fifth-grade students enrolled across 3 schools. Two schools receiving the *Brighter Bites* intervention and 1 was the usual care comparison school (intervention school 1: n = 44 children; intervention school 2: n = 32 children; comparison school: n = 39 children).

Table 2. Changes in F&V Selection, Waste and Related Nutrients Waste, *Brighter Bites* Plate Waste Study, 2017–2018

Observations, n	**Wave 1 (Baseline)**	**Wave 2 (End of Fall)**	**Wave 3 (Start of Spring)**	**Wave 4 (End of Spring)**
Intervention group, n	295	308	263	310
Control group, n	130	121	96	102
Proportion of F&V sides selected per meal[a]				
Intervention group, mean (SD)	0.2 (0.1)	0.2 (0.2)	0.2 (0.2)	0.2 (0.2)
Control group, mean (SD)	0.4 (0.2)	0.3 (0.1)	0.3 (0.2)	0.4 (0.1)
Net changes in proportion of F&V side dishes selected,[b] β (95% CI)	Reference	0.1 (0.1 to 0.1)	0.1 (0.1 to 0.2)	0.1 (0.0–0.1)
P		<.001[c]	<.001[c]	.001[c]
Amount of F&V wasted per meal, g				
Intervention group, mean (SD)	88.9 (74.5)	79.7 (62.2)	78.2 (57.6)	63.0 (51.2)
Control group, mean (SD)	67.9 (50.4)	68.1 (53.7)	55.8 (43.3)	74.6 (54.1)
Net changes in weight of food wasted,[b] β (95% CI)	Reference	−8.1 (−24.3 to 8.2)	1.4 (−15.9 to 18.6)	−32.1 (−48.9,−15.2)
P		.33	.88	<.001[c]
Amount wasted per F&V item, g				
Intervention group, mean (SD)	60.6 (51.7)	50.7 (40.4)	50.9 (45.7)	43.0 (40.6)
Control group, mean (SD)	46.0 (38.3)	48.8 (37.5)	40.3 (34.3)	58.1 (42.3)
Net changes in weight of food wasted,[b] β (95% CI)	Reference	−11.5 (−21.5 to −1.50)	−3.3 (−14.0 to 7.4)	−28.0 (−39.7 to −18.4)
P		.02[c]	.55	<.001[c]
Total energy wasted, kcal				
Intervention group, mean (SD)	58.9 (61.3)	46.0 (45.8)	49.3 (48.5)	37.5 (38.2)
Control group, mean (SD)	46.6 (42.3)	48.7 (43.0)	32.6 (41.0)	45.6 (45.4)
Net changes in energy wasted,[b] β (95% CI)	Reference	−14.1 (−27.4 to −0.9)	4.6 (−9.5 to 18.6)	−19.6 (−33.3 to −5.9)
P		.04[c]	.52	.005[c]
Total carbohydrates wasted, g				
Intervention group, mean (SD)	12.6 (11.2)	10.2 (9.7)	11.0 (9.7)	8.7 (8.0)
Control group, mean (SD)	10.0 (8.8)	10.0 (8.3)	7.4 (9.1)	10.6 (10.4)
Net changes in total carbohydrates wasted,[b] β (95% CI)	Reference	−2.28 (−5.0 to 0.4)	1.1 (−1.7 to 4.0)	−4.3 (−7.0 to −1.5)
P		.09	.44	.002
Total protein wasted, g				
Intervention group, mean (SD)	1.0 (1.5)	0.8 (1.4)	0.7 (1.0)	0.5 (0.7)
Control group, mean (SD)	1.0 (1.6)	1.2 (1.9)	0.9 (1.8)	1.2 (1.8)
Net changes in protein wasted,[b] β (95% CI)	Reference	−0.4 (−0.8 to −0.0)	−0.2 (−0.6 to 0.2)	−0.6 (−1.0 to −0.2)
P		.05[c]	.31	.003[c]
Total fat wasted, g				
Intervention group, mean (SD)	1.0 (2.2)	0.6 (1.1)	0.7 (1.8)	0.4 (1.4)
Control group, mean (SD)	0.7 (1.1)	0.8 (1.3)	0.2 (0.3)	0.2 (0.5)
	Reference	−0.6 (−1.0 to −0.2)	0.1(−0.3 to 0.6)	−0.1(−0.6 to 0.3)

(continued)

Table 2. (*Continued*)

Observations, n	Wave 1 (Baseline)	Wave 2 (End of Fall)	Wave 3 (Start of Spring)	Wave 4 (End of Spring)
Net changes in total fat wasted,[b] β (95% CI)				
P		.006[c]	0.63	.52
Total dietary fiber wasted, g				
Intervention group, mean (SD)	1.8 (2.0)	1.5 (1.8)	1.7 (1.8)	1.3 (1.4)
Control group, mean (SD)	1.5 (1.5)	1.5 (1.5)	1.5 (2.4)	1.8 (2.4)
Net changes in fiber wasted,[b] β (95% CI)	Reference	−0.2 (−0.8 to 0.3)	−0.1 (−0.6 to 0.5)	−0.7 (−1.2 to −0.2)
P		.35	.75	.009[c]
Vitamin B_1 (thiamine) wasted, mg				
Intervention group, mean (SD)	0.045 (0.05)	0.042 (0.05)	0.035 (0.04)	0.025 (0.03)
Control group, mean (SD)	0.041 (0.03)	0.043 (0.04)	0.034 (0.05)	0.048 (0.07)
Net changes in vitamin B_1 (thiamine) wasted,[b] β (95% CI)	Reference	−0.003 (−0.02 to 0.010)	−0.002 (−0.02 to 0.01)	−0.03 (−0.04 to −0.01)
P		.63	.77	.001[c]
Vitamin B_2 (riboflavine) wasted, mg				
Intervention group, mean (SD)	0.036 (0.03)	0.026 (0.02)	0.026 (0.02)	0.022 (0.02)
Control group, mean (SD)	0.034 (0.04)	0.038 (0.04)	0.028 (0.03)	0.029 (0.03)
Net changes in vitamin B_2 (riboflavine) wasted,[b] β (95% CI)	Reference	−0.01 (−0.02 to −0.005)	−0.003 (−0.01 to 0.005)	−0.008 (−0.02 to .001)
P		.001[c]	.41	.06
Vitamin B_3 (niacin) wasted, mg				
Intervention group, mean (SD)	0.47 (0.52)	0.35 (0.35)	0.37 (0.40)	0.27 (0.32)
Control group, mean (SD)	0.37 (0.35)	0.35 (0.33)	0.25 (0.30)	0.43 (0.40)
Net changes in vitamin B_3 (niacin) wasted,[b] β (95% CI)	Reference	−0.09 (−0.19 to 0.02)	0.03 (−0.09 to 0.14)	−0.26 (−0.37 to −0.15)
P		.11	.70	.001[c]
Vitamin B_6 (pyridoxine, pyridoxyl, and pyridoxamine) wasted, mg				
Intervention group, mean (SD)	0.07 (0.08)	0.06 (0.06)	0.06 (0.07)	0.05 (0.06)
Control group, mean (SD)	0.09 (0.12)	0.08 (0.10)	0.07 (0.12)	0.10 (0.15)
Net changes in vitamin B_6 wasted,[b] β (95% CI)	Reference	−0.0007 (−0.03 to 0.02)	0.009 (−0.02 to 0.04)	−0.03 (−0.06 to −0.005)
P		.95	.57	.02[c]
Total folate wasted, µg				
Intervention group, mean (SD)	13.3 (21.6)	14.9 (27.1)	12.3 (17.2)	9.5 (14.1)
Control group, mean (SD)	12.9 (17.2)	15.1 (23.1)	17.1 (30.4)	16.3 (30.8)
Net changes in total folate wasted,[b] β (95% CI)	Reference	−0.33 (-6.7,6.0)	−5.1 (−11.8 to 1.7)	−6.9 (−13.5 to −0.4)
P		.93	.14	.04[c]

(continued)

Table 2. (*Continued*)

Observations, n	Wave 1 (Baseline)	Wave 2 (End of Fall)	Wave 3 (Start of Spring)	Wave 4 (End of Spring)
Vitamin B_{12} (cobalamin) wasted, μg				
Intervention group, mean (SD)	0.007 (0.03)	0.006 (0.02)	0.004 (0.02)	0.0002 (0.002)
Control group, mean (SD)	0.0001 (0.0005)	0.0001 (0.0005)	0.00004 (0.0003)	0.00009 (0.0005)
Net changes in vitamin B_{12} (cobalamin) wasted,[b] β (95% CI)	Reference	−0.0009 (−0.006 to 0.004)	−0.002 (−0.008 to 0.003)	−0.006 (−0.01 to −0.001)
P		.71	.34	.01[c]
Vitamin C (ascorbic acid) wasted,[d] mg				
Intervention group, mean (SD)	5.6 (5.9)	6.6 (9.2)	6.8 (9.1)	6.1 (10.8)
Control group, mean (SD)	6.9 (7.3)	6.1 (6.2)	3.0 (4.4)	4.1 (4.8)
Net changes in vitamin C wasted,[b] β (95% CI)	Reference	1.7 (−0.6 to 4.0)	4.9 (2.5 to 7.4)	3.0 (0.7 to 5.4)
P		.15	<.001[c]	.01[c]
Vitamin E (total α-tocopherol) wasted, mg				
Intervention group, mean (SD)	0.33 (0.32)	0.33 (0.39)	0.38 (0.41)	0.26 (0.32)
Control group, mean (SD)	0.25 (0.32)	0.23 (0.31)	0.09 (0.12)	0.18 (0.19)
Net changes in vitamin E (total α-tocopherol) wasted,[b] β (95% CI)	Reference	0.02 (−0.07 to 0.12)	0.20 (0.10 to 0.29)	−0.008 (−0.10 to 0.09)
P		.60	<.01[c]	.83
Vitamin K (phylloquinone) wasted, μg				
Intervention group, mean (SD)	7.3 (13.3)	7.1 (12.8)	6.9 (9.5)	5.6 (11.5)
Control group, mean (SD)	8.1 (15.9)	7.4 (22.5)	3.8 (6.8)	4.2 (7.0)
Net changes in vitamin K (phylloquinone) wasted,[b] β (95% CI)	Reference	0.8 (−2.9 to 4.5)	4.1 (0.2 to 8.1)	2.5 (−1.3 to 6.3)
P		.67	.04[c]	.20
Calcium wasted, mg				
Intervention group, mean (SD)	14.3 (21.6)	13.7 (14.3)	13.7 (14.7)	8.9 (10.2)
Control group, mean (SD)	16.1 (19.5)	12.9 (13.4)	9.9 (14.9)	12.0 (15.4)
Net changes in calcium wasted,[b] β (95% CI)	Reference	2.5 (−1.9 to 6.8)	4.6 (−0.06 to 9.2)	−1.7 (−6.2 to 2.8)
P		.27	.05	.45
Iron wasted, mg				
Intervention group, mean (SD)	0.30 (0.33)	0.29 (0.39)	0.25 (0.27)	0.19 (0.25)
Control group, mean (SD)	0.40 (0.47)	0.39 (0.50)	0.27 (0.51)	0.38 (0.54)
Net changes in iron wasted,[b] β (95% CI)	Reference	0.01 (−0.10 to 0.12)	0.08 (−0.03 to 0.20)	−0.07 (−0.18 to 0.03)
P		.85	.15	.18

CI indicates confidence interval; F&V, fruits and vegetables.
[a]Proportion of F&V side dishes selected per meal is F&V side dishes selected per meal divided by F&V side dishes available per meal; [b]Coefficient from interaction term *wave* × *intervention* in mixed-effect linear regression models with plate waste measures clustered within child, adjusted for school as a covariate in the analysis; [c]Significance at $P < .05$; [d]Summation of weight of food wasted per meal, assuming weight of food wasted equals weight of sample food item if it was totally unconsumed.
Notes: Study population was fourth- to fifth-grade students enrolled across 3 schools. Two schools receiving the *Brighter Bites* intervention and 1 was the usual care comparison school (final sample size for pre–post analysis = 91 students).

weeks ($P < .01$) and the end of the intervention ($P < .01$). With regard to micronutrients, there was a significant decrease in waste in the amount of dietary fiber (gm) at wave 4; vitamins B_1, B_3, and B_6 (mg), total folate (μg), and vitamin B_{12} (μg) ($P < .05$). Conversely, there were greater decreases in vitamins C and K (mg) wasted among children in the comparison school measured against those participating in *Brighter Bites* ($P < .05$).

DISCUSSION

Overall, the results of this pilot plate waste study demonstrated a significant, although small, decrease from baseline to the end of the intervention in the amount of F&V wasted among children participating in *Brighter Bites*, compared with those not participating in the program. Moreover, the decrease in the amount of F&V wasted at school lunches was significant at the end of the 16-week intervention, but not at the midpoint (8 weeks); this potentially indicates the need for longer-term exposure to F&V to promote behavior change.

This study adds to the current body of literature on measuring F&V waste among children participating in the NSLP[20] by using objective measures and measuring the type and amount of F&V wasted. These results concur with those of other studies that assessed the impact of school-based interventions and policy change on plate waste at school meals and found that modifying the availability and accessibility of F&V in schools improved consumption and decreased waste at school meals.[21−23] The results of this study also demonstrated significant, although small, reductions in waste of nutrients such as dietary fiber and vitamins among children participating in *Brighter Bites*, measured against those in the comparison group. Nutrient waste because of food waste is a major issue in the US. A study by Spiker et al[24] using national data reported a significant amount of F&V and related nutrient waste at the retail and consumer levels in the US amounting to dietary fiber waste equivalent to 23% of the recommended dietary allowance for Americans. Nutrients such as dietary fiber, vitamins, and folate are the building blocks of life and are critical for preventing chronic disease[25−27]; strategies to promote consumption and reduce waste of these key nutrients should be employed. Recent systematic reviews of the literature also indicated that school-based interventions that involve parents and improve the home environment can support child energy-balance behaviors and health.[28]

Baseline data from the current study found that regardless of the number of F&V selections offered, children selected a small number of F&V at school lunches and wasted a substantial proportion of those selected. These results concur with those of Gase et al[11]: in an effort to characterize student receptivity to new menu offerings at school lunch in Los Angeles, CA, those authors reported that a significant proportion of children did not consume F&V offered at school lunch because they either did not select F&V or threw away all of the F&V without taking a bite.

Limitations

Limitations of the study include a small sample size with 1 comparison and 2 intervention schools that was not powered for outcomes or cluster effects. This was a pilot study and was not statistically powered to detect changes in the outcomes measured. Furthermore, sociodemographic data were not collected at the individual child or family level, which could be potential covariates in the analysis. Also, because students were clustered within schools, a 3-level multilevel model adjusting for within- and between-school variance would have been the preferred method of analysis. However, because of the small sample size at the school level, a multilevel model adjusting for school-level variance was not performed, which might have resulted in an underestimation of the SEs of regression coefficients and a subsequent potential overstatement of statistically significant findings. Moreover, factors such as the timing of school recess (before or after lunch) may vary among schools and influence findings. However, these data were not collected in the current study. The retention rate with regard to plate waste measurement was lower in the comparison school; more children brought lunches from home, compared with the 2 intervention schools. This differential attrition could have biased the overall findings, likely away from the null. Despite multiple reminders regarding the purpose of the study, children bringing home lunches continued to be a challenge. This needs to be considered in longitudinal plate waste assessments. Also, the attendance rate for *Brighter Bites* distributions was lower in intervention school 2 compared with intervention school 1, which could have attenuated the findings of the current study. Finally, a limitation is that changes in F&V waste and nutrients lost might have resulted from changes in consumption of other components of the meal and not from the intervention itself.

IMPLICATIONS FOR RESEARCH AND PRACTICE

School-based nutrition interventions may improve F&V intake among children during school lunch. Strategies such as those used by *Brighter Bites* to engage parents in a F&V co-op, teaching them how to use the produce provided, and how to improve the home nutrition environment, may hold promise in improving healthy dietary intake among children from low-income populations. However, future studies including a larger sample size with a more stringent, fully powered, 3-level, cluster-randomized, controlled trial design are needed. Future studies might also assess the whole meal (vs only F&V), consider other covariates such as school recess time, and assess dose−response relations between frequency of exposure to F&V and food waste. By collaborating with community partners and nutrition educators in implementing school-based nutrition programs that include provision of healthy foods such as F&V plus nutrition education, school districts may effectively reduce F&V waste in school lunches and improve the dietary intakes of children, especially those from lower socioeconomic populations.

ACKNOWLEDGMENTS

The authors acknowledge Feeding Texas, *Brighter Bites*, and the Michael and Susan Dell Center for Healthy Living for their support of the study. They also acknowledge the Houston Independent School District and Dallas Independent School District for their support of the study.

REFERENCES

1. US Department of Health and Human Services, US Department of Agriculture. *Dietary Guidelines for Americans, 2005*. 6th ed. Washington, DC: US Government Printing Office; 2005.
2. WHO. Global strategy on diet, physical activity and health. Updated 2018. http://www.who.int/dietphysicalactivity/childhood_consequences/en/. Accessed September 25, 2018.
3. Zarnowiecki DM, Dollman J, Parletta N. Associations between predictors of children's dietary intake and socioeconomic position: A systematic review of the literature. *Obes Rev*. 2014;15:375–391.
4. Ogden CL, Lamb MM, Carroll MD, Flegal KM. Obesity and socioeconomic status in adults: United States 1988−1994 and 2005−2008. *NCHS Data Brief*. 2010;50:1–8.
5. School Nutrition Association. School meal trends & stats. Updated 2017. http://www.schoolnutrition.org/AboutSchoolMeals/School-Meal-TrendsStats. Accessed January 20, 2019.
6. US Department of Agriculture, Food and Nutrition Service. SP 45-2013: Updated Offer versus Serve Guidance for the National School Lunch Program and School Breakfast Program in School Year 2013-2014. Updated 2013. Available at: https://www.fns.usda.gov/sp-45-2013-updated-offer-versus-serve-guidance-national-school-lunch-program-and-school-breakfast. Accessed June 27, 2019.
7. Cohen JF, Richardson S, Austin SB, Economos CD, Rimm EB. School lunch waste among middle school students: nutrients consumed and costs. *Am J Prev Med*. 2013;44:114–121.
8. Cohen JF, Richardson S, Parker E, Catalano PJ, Rimm EB. Impact of the new U.S. Department of Agriculture school meal standards on food selection, consumption, and waste. *Am J Prev Med*. 2014;46:388–394.
9. Buzby JC, Guthrie JF. Plate waste in school nutrition programs. Report to Congress. Washington, DC: US Department of Agriculture, Economic Research Service; 2002. Available at: https://www.ers.usda.gov/webdocs/publications/43131/31216_efan02009.pdf?v=41423. Accessed August 28, 2019.
10. Byker CJ, Farris AR, Marcenelle M, Davis GC, Serrano EL. Food waste in a school nutrition program after implementation of new lunch program guidelines. *J Nutr Educ Behav*. 2014;46:406–411.
11. Gase LN, McCarthy WJ, Robles B, Kuo T. Student receptivity to new school meal offerings: assessing fruit and vegetable waste among middle school students in the Los Angeles Unified School District. *Prev Med*. 2014;67 (suppl 1):S28–S33.
12. Huang Z, Gao R, Bawuerjiang N, Zhang Y, Huang X, Cai M. Food and nutrients intake in the school lunch program among school children in Shanghai, China. *Nutrients*. 2017;9:582.
13. Sharma SV, Markham C, Chow J, Ranjit N, Pomeroy M, Raber M. Evaluating a school-based fruit and vegetable co-op in low-income children: A quasi-experimental study. *Prev Med*. 2016;91:8–17.
14. Bandura A. *Social Foundations of Thought and Action: A Social Cognitive Theory*. Englewood Cliffs, NJ: Prentice-Hall; 1986.
15. Hoelscher DM, Springer AE, Ranjit N, et al. Reductions in child obesity among disadvantaged school children with community involvement: the Travis County CATCH trial. *Obesity*. 2010;18:S36–S44.
16. Luepker R, Perry C, McKinlay S, et al. Outcomes of a field trial to improve children's dietary patterns and physical activity. The Child and Adolescent Trial for cardiovascular Health. CATCH collaborative group. *JAMA*. 1996;275:768–776.
17. Cole E, Pisano ED, Clary GJ, et al. A comparative study of mobile electronic data entry systems for clinical trials data collection. *Int J Med Inform*. 2006;75:722–729.
18. Murray DM, Varnell SP, Blitstein JL. Design and analysis of group-randomized trials: a review of recent methodological developments. *Am J Public Health*. 2004;94:423–432.
19. Shadish WR, Cook TD, Campbell DT. *Experimental and Quasi-Experimental Designs for Generalized Causal Inference*. 2nd ed. Boston, MA: Houghton Mifflin; 2002.
20. Byker Shanks C, Banna J, Serrano EL. Food waste in the National School Lunch Program 1978−2015: A systematic review. *J Acad Nutr Diet*. 2017;117:1792–1807.
21. Just DR, Wansink B, Hanks AS. Chefs move to schools. A pilot examination of how chef-created dishes can increase school lunch participation and fruit and vegetable intake. *Appetite*. 2014;83:242–247.
22. Just D, Price J. Default options, incentives and food choices: evidence from elementary-school children. *Public Health Nutr*. 2013;16:2281–2288.
23. Wansink B, Just DR, Hanks AS, Smith LE. Pre-sliced fruit in school cafeterias: children's selection and intake. *Am J Prev Med*. 2013;44:477–480.
24. Spiker ML, Hiza HA, Siddiqi SM, Neff RA. Wasted food, wasted nutrients: nutrient loss from wasted food in the United States and comparison to gaps in dietary intake. *J Acad Nutr Diet*. 2017;117:1031–1040.e22.
25. Dahl WJ, Stewart ML. Position of the academy of nutrition and dietetics: health implications of dietary fiber. *J Acad Nutr Diet*. 2015;115:1861–1870.
26. O'Neil CE, Nicklas TA, Fulgoni VL. Consumption of apples is associated with a better diet quality and reduced risk of obesity in children: National Health and Nutrition Examination Survey (NHANES) 2003−2010. *Nutr J*. 2015;14:48.
27. Wu L, Sun D, He Y. Fruit and vegetables consumption and incident hypertension: dose−response meta-analysis of prospective cohort studies. *J Hum Hypertens*. 2016;30:573–580.
28. Verjans-Janssen SRB, van de Kolk I, Van Kann DHH, Kremers SPJ, Gerards SMPL. Effectiveness of school-based physical activity and nutrition interventions with direct parental involvement on children's BMI and energy balance-related behaviors - A systematic review. *PLOS ONE*. 2018;13:e0204560.

CONFLICT OF INTEREST

S. Sharma serves on the Board of Directors for Brighter Bites nonprofit organization. This is an unpaid board position. The rest of the authors declare that they have no relevant conflicts of interest.