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Short communication

Salad bars and energy intake in Virginia elementary schools with free meals

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ABSTRACT

School salad bars are widely promoted as a means to increase adherence to National School Lunch Program (NSLP) nutrition mandates. Yet it is unknown how salad bars or fruit and vegetable (F&V) intake relates to energy intake within the NSLP, or if F&Vs displace energy from other sources. This relation is particularly important to understand among children from minoritized backgrounds, who are at high risk of obesity and food insecurity, and the most likely to be impacted by school food policies, given their reliance on school meals. This study purpose was to evaluate if school salad bars and F&V intake are associated with lower lunch energy intake. Energy intake in Virginia elementary schools with and without salad bars, and associations between F&V energy and other energy sources, were examined. Cross-sectional plate waste assessments were conducted in matched school pairs (3 with, 3 without salad bars; N = 1,102 students; >90% Black and Latinx; 100% free meals). Two-level hierarchical models assessed group differences in energy intake and the proportion of energy from each meal component. Mean total lunch energy intake was 304 ± 157 kcal (salad bar); 269 ± 152 kcal (no salad bar). Students in salad bar schools consumed more energy from vegetables (+11 kcal; $P < .001$). Energy intake patterns were inconsistent across pairs. F&V energy was not associated with non-F&V energy ($F = 1.04$, $P = .31$). Findings do not suggest that salad bars were associated with lower energy intake. Evidence was inconsistent regarding F&V displacement of other lunch calories. Further research regarding F&V, salad bars, and energy intake is needed.

1. Introduction

School salad bars are highlighted as a strategy to facilitate achievement of the National School Lunch Program (NSLP) standards regarding fruit and vegetable (F&V) variety and quantity (US Department of Agriculture, 2012). Salad bars expose children to a greater variety of F&Vs and foster choice (Harris et al., 2012). However, little research has examined the influence of F&V intake and/or salad bars on children's energy intake within the NSLP (Bontrager Yoder and Schoeller, 2014; Rolls et al., 2004; Ledoux et al., 2011). Specifically, it is unknown if F&Vs displace calories from other (higher energy dense) sources, thus have a potential role in obesity prevention. One study found that increased F&V intake at lunch was associated with decreased self-reported energy intake in schools with salad bars (Slusser et al., 2007). Conversely, another investigation (Bontrager Yoder and Schoeller, 2014) found that lunches with the greatest F&V consumption included the most calories. Thus, it is not clear if salad bars, or F&V intake, yield energy displacement. To our knowledge, no studies have investigated differences in objectively-assessed energy intake in schools with and without salad bars. This relation is particularly important to understand among children from minoritized backgrounds, who are at high risk of obesity and food insecurity, and the most likely to be impacted by school food policies, given their reliance on school meals (Mirtcheva and Powell, 2009).

This report is part of a larger study of school salad bars, in which higher vegetable intake was observed in schools with salad bars compared to those without salad bars (Bean et al., 2020). To enhance understanding of how salad bars relate to F&V intake in schools, this study evaluated differences in energy intake in matched school pairs, with and without salad bars. Specifically, this study evaluated: energy

Abbreviations: F&V, fruits and vegetables; NSLP, National School Lunch Program.

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intake for the total school lunch and all meal components, whether the proportion of energy consumed from F&Vs differed based on salad bar presence, and the association between F&V energy and other lunch energy sources. The null hypothesis was that students' energy intake in schools with and without salad bars would not differ.

2. Methods

2.1. Design and participants

This cross-sectional study was conducted in 2016 in a school district with universal free meals, in which some schools had salad bars (serving F&V only) and some did not (only served pre-portioned F&V), yet the remainder of the menus were matched (see (Bean et al., 2020; Adams et al., 2020) for complete methods, including F&Vs offered at each school; and see (Bean et al., 2018) describing the initial salad bar program launch). Schools with and without salad bars were matched on school food environment (adherence to Smarter Lunchroom principles, assessed previously (Bean et al., 2019)) and student race/ethnicity (above or below 85% Black/Latinx [due to higher obesity risk among these racial/ethnic groups]). Three pairs of schools (one school with a salad bar and one school without a salad bar in each pair) were then randomly selected using a random number generator. Pair 1 was > 1SD below the district's mean Smarter Lunchroom score (suggesting a less favorable school food environment); Pairs 2 and 3 were both > 1SD above the Smarter Lunchroom mean. Selected pairs all had ≥ 85% Black/Latinx children (1%-38% Latinx; 57–97% Black across schools). All students in 1st-5th grades receiving school lunch on rating days were eligible; (86%-100% NSLP participation across schools). Parents could opt their child out by returning a parent notification letter. Student verbal assent was obtained in the lunch line. (Opt out rate was 3.1% salad bar schools; 2.8% comparison schools, $P = 0.73$). This study was approved by [Virginia Commonwealth University's] Institutional Review Board.

2.2. Procedures

Validated digital imagery plate waste methods were implemented (Taylor et al., 2014; Bean et al., 2018). Each school pair was rated once, with pairs rated on the same day to match menu and day. As students exited the lunch line, staff obtained verbal assent and placed a numbered label (indicating grade and sex) on students' trays. Staff then took a "pre-consumption" photograph. After lunch, students left their trays on the table. Staff removed obstructions (e.g., napkins), poured remaining beverages into a transparent plastic measuring cup, and took "post-consumption" images. Photographs were taken from a ~45° angle using iPads.

To quantify starting portions, researchers took photographs and obtained weights (using a calibrated Ozeri Pronto Digital Food Scale [Model ZK14-S]) of 3 reference portions of all lunch foods offered. An average weight was used as a reference portion for each item. For self-serve salad bar items (with variable starting portions), two reference portions were created independently in the laboratory in ¼ cup, ½ cup, and ¾ cup portions, as previously described (Bean et al., 2018). Each portion was weighed and photographed and an average used as the reference weight. Recipes and brands of all items were obtained from the district dietitian and entered into Nutrition Data Systems for Research (NDSR; Nutrition Coordinating Center, Minneapolis, MN, 2016) to obtain nutritional information.

In the laboratory, raters with established interrater reliabilities (intraclass correlations [ICC] = 0.84–0.94 at study onset) simultaneously viewed pre-and post-consumption images. Using reference portion photographs and a pie chart (Connors and Rozell, 2004) as visual aids, they rated for each tray: items selected, starting portions of self-serve salad bar items (to nearest ¼ cup), and how much remained of each item, in 20% increments (Taylor et al., 2014; Bean et al., 2018; Williamson et al., 2003). Beverages were rated to the nearest ½ ounce, using measuring cup markings. A random sample of ~20% of trays was independently double rated (ICC's = 0.81–0.90). Methods for estimating salad bar starting portions and waste have been validated in the laboratory (Bean et al., 2018).

2.3. Measures

Whole F&Vs were categorized as "fruits" or "vegetables" in analyses; F&Vs that were part of entrées were included with the entrées, and 100% fruit juice was categorized as a beverage. Energy consumption (kcal) was calculated for the total meal, fruits, vegetables, entrées, snacks, condiments, and beverages, each evaluated as outcomes, as described: 1) the energy value for each component on each tray was extracted from NDSR; 2) this value was multiplied by %consumed, estimated as 1-plate waste score; 3) the kcal for the total meal was then determined by adding the kcal consumed of all components. Proportions of energy for the whole meal attributed to each component were also evaluated as outcomes. Proportions were calculated by dividing the energy consumed of the respective component by total energy.

2.4. Analysis

The initial sample had n = 1,326 trays with all meal components rated. Trays with supplementary food or beverages (e.g., items not offered at school; n = 171 [83 salad bar, 88 comparison]) were excluded as comparable nutritional analyses could not be applied. To minimize variation in energy due to the entrée, students who selected an entrée (e.g., leftovers) not offered at both schools within a pair were excluded (n = 53 trays [44 salad bar, 9 comparison]). Thus, n = 1,102 trays were available for analyses (n = 500 with a salad bar; n = 602 comparison). Trays with 100% plate waste (n = 21) were excluded only from analyses examining the proportion of total energy consumed attributed to each component.

Differences in energy intake (kcals) for the total lunch and all meal components between schools with and without salad bars were evaluated using 2-level hierarchical models. The unit of analysis was the individual tray. ICCs for school level clustering ranged from 0.29 for kcal consumed from entrées to ~0.15 for kcal consumed from the total meal and from vegetables; all remaining meal components ICCs were < 0.06. For all models, random effects were estimated for the intercept, clustering within schools. Covariates included the level 1 fixed effects of sex (male = 1, female = 2) and grade, and the level 2 fixed effect of school pair (designated as 1, 2, and 3), as the specific school lunch environment might influence results. The interaction between group and school pair was included in initial models. If this interaction was nonsignificant, it was removed and the model reapplied so that salad bar group main effects could be evaluated. *F*- and *P*-values for group, school pair, and the interaction are presented. Significant interactions were observed in many of the models, prohibiting interpretation of salad bar group effects. Thus, to explore group effects on outcomes, post-hoc tests using generalized linear models were conducted, stratifying by pair, with grade and sex as covariates. Separate results were obtained for each pair. To evaluate whether F&V energy was associated with non-F&V energy (entrée + snack + beverage + condiment), a 2-level hierarchical model was applied, controlling for salad bar group and clustering within school. Analyses were conducted using SAS v9.4 (SAS Institute, 2013). A Bonferroni correction was applied to account for multiple comparisons (n = 39, setting the P for significance at < 0.002).

3. Results

Table 1 presents mean (SD) energy consumption for the total meal, each component, and the proportion of total energy consumed attributed to each meal component. Mean total energy selected was 550 ± 139 kcal (454–690 kcal across schools); mean energy intake ranged from

Table 1
Mean (SD) Lunch Energy (Kcal) Consumed Overall and by Pair with Fixed Effects for 2-Level Hierarchical Models Assessing Group (Salad Bar vs. No Salad Bar) Differences in Energy Intake and Proportion of the Meal Consumed Attributed to Each Meal Component.

	Overall		Pair 1		Pair 2		Pair 3		Group	Pair	Group × Pair
	Salad Bar	No Salad Bar	Salad Bar	No Salad Bar	Salad Bar	No Salad Bar	Salad Bar	No Salad Bar			
Kcal	n = 500 M (SD)	n = 602 M (SD)	n = 136 M (SD)	n = 248 M (SD)	n = 207 M (SD)	n = 182 M (SD)	n = 157 M (SD)	n = 172 M (SD)	*F*-value (*P*)	*F*-value (*P*)	*F*-value (*P*)
Total Meal	304 (157)	269 (152)	306 (156)	231 (135)	236 (127)	256 (126)	394 (147)	336 (176)	15.85 (<0.001)	66.52 (<0.001)	**11.02 (<0.001)**
Fruits	17 (22)	24 (27)	17 (29)	22 (26)	18 (18)	21 (30)	15 (21)	31 (25)	28.83 (<0.001)	2.60 (0.08)	**7.22 (<0.001)**
Vegetables	35 (42)	23 (42)	42 (48)	36 (50)	45 (43)	28 (41)	16 (26)	1 (5)	**24.08 (<0.001)**	**60.72 (<0.001)**	2.25 (0.11)
Entrées	191 (143)	170 (143)	185 (123)	126 (118)	107 (91)	144 (95)	307 (137)	261 (174)	8.31 (0.004)	158.96 (<0.001)	**15.56 (<0.001)**
Snacks	18 (55)	13 (52)	18 (49)	1 (8)	25 (70)	23 (69)	10 (34)	20 (64)	1.39 (0.24)	7.28 (<0.001)	5.55 (0.004)
Condiments	6 (18)	2 (13)	9 (19)	4 (17)	2 (8)	3 (14)	9 (24)	0 (2)	20.36 (<0.001)	6.21 (0.003)	**11.21 (<0.001)**
Beverages	39 (46)	37 (46)	36 (47)	44 (49)	40 (45)	39 (48)	39 (48)	23 (35)	0.57 (0.45)	3.74 (0.025)	6.22 (0.003)
Proportion of Meal	n = 492	n = 589	n = 130	n = 240	n = 206	n = 178	n = 156	n = 171	*F*-value (*P*)	*F*-value (*P*)	*F*-value (*P*)
Fruits	0.07 (0.12)	0.12 (0.18)	0.06 (0.11)	0.13 (0.19)	0.11 (0.15)	0.09 (0.13)	0.04 (0.07)	0.14 (0.21)	24.85 (<0.001)	0.19 (0.84)	**16.41 (<0.001)**
Vegetables	0.14 (0.19)	0.09 (0.18)	0.14 (0.18)	0.15 (0.23)	0.21 (0.22)	0.11 (0.16)	0.04 (0.09)	0.00 (0.01)	13.81 (<0.001)	57.25 (<0.001)	**8.32 (<0.001)**
Entrées	0.56 (0.31)	0.56 (0.33)	0.56 (0.28)	0.45 (0.35)	0.42 (0.31)	0.56 (0.29)	0.76 (0.20)	0.70 (0.29)	0.04 (0.85)	66.00 (<0.001)	**18.09 (<0.001)**
Snacks	0.06 (0.16)	0.03 (0.13)	0.06 (0.17)	0.00 (0.03)	0.07 (0.20)	0.06 (0.17)	0.02 (0.09)	0.06 (0.17)	2.53 (0.12)	5.63 (0.004)	**7.50 (<0.001)**
Condiments	0.02 (0.07)	0.01 (0.07)	0.04 (0.11)	0.02 (0.07)	0.00 (0.02)	0.02 (0.09)	0.03 (0.08)	0.00 (0.00)	7.06 (0.008)	5.08 (0.007)	**7.91 (<0.001)**
Beverages	0.16 (0.23)	0.18 (0.26)	0.15 (0.24)	0.25 (0.32)	0.19 (0.25)	0.17 (0.22)	0.12 (0.17)	0.10 (0.18)	1.84 (0.18)	14.53 (<0.001)	**7.40 (<0.001)**

Note: $P < .002$ indicates significance (bolded), after Bonferroni correction applied. Models account for sex, grade, and clustering within schools; Pair refers to matched pairs of schools with and without a salad bar. Pairs were matched based on % racial/ethnic minoritized (above or below 85% minoritized) and the lunchroom environment (distance from the mean Smarter Lunchroom score). Group differences in models with significant group × pair interactions cannot be interpreted, thus main effects are not bolded.

231 to 394 kcal across schools. The group*pair interaction was not significant for vegetable energy consumption; thus the model was reapplied without the interaction. Although pair differences were observed (*F*-value = 64.27, $P < .001$), students in salad bar schools consumed more energy from vegetables (+11 kcal; *F*-value = 24.42, $P < .001$) than comparison school students. For most of the remaining models, the group*pair interaction was significant, prohibiting interpretation of group main effects. Results from the 2-level hierarchical model, controlling for salad bar group and accounting for clustering within schools, showed that F&V energy was not associated with non-F&V energy (*F*-value = 1.04, $P = .31$).

Results from generalized linear models assessing group (salad bar vs. comparison) by pair are in Table 2. In Pair 1, the salad bar school had higher total energy intake than the comparison (+75 kcal, $P < .001$), with no differences in Pair 2 or 3. Salad bar schools had greater energy intake from vegetables in Pair 2 (+17 kcal) and Pair 3 (+15 kcal) and less energy from fruits in Pair 3 (−16 kcal, *P*'s < 0.001). Vegetable energy constituted a greater proportion of total meal energy in the salad bar school in Pair 2 (21%, $P < .001$) and Pair 3 (4%, $P < .001$), compared with their matched comparison (11% and 0%, respectively). In contrast, energy from fruit constituted a lower proportion of the total meal energy in the salad bar school for Pair 1 (6%, $P < .001$) and Pair 3 (4%, $P < .001$), compared with matched comparisons (13% and 14%, respectively).

4. Discussion

This study investigated how school salad bars relate to energy intake, and the associations between F&V intake and other sources of lunch

Table 2
Lunch Energy Intake (kcal) from Salad Bar and Comparison (No Salad Bar) Schools for the Total Meal and Each Meal Component (n = 1,102) and Proportion of the Lunch Meal Attributed to Each Component (n = 1,081), by Pair.

	Pair 1 χ^2 (*P*-value)	Pair 2 χ^2 (*P*-value)	Pair 3 χ^2 (*P*-value)
Kcal			
Total Meal	**22.13 (<0.001)**	0.77 (0.38)	9.11 (0.003)
Fruits	6.18 (0.013)	0.00 (0.96)	**42.21 (<0.001)**
Vegetables	0.29 (0.60)	**17.28 (<0.001)**	**53.92 (<0.001)**
Entrées	**21.35 (<0.001)**	8.84 (0.003)	6.13 (0.014)
Snacks	**31.98 (<0.001)**	0.86 (0.36)	3.06 (0.09)
Condiments	6.56 (0.011)	2.39 (0.13)	**26.72 (<0.001)**
Beverages	0.74 (0.39)	1.82 (0.18)	**11.75 (<0.001)**
Proportion of Meal			
Fruits	**18.42 (<0.001)**	4.96 (0.026)	**32.44 (<0.001)**
Vegetables	0.43 (0.51)	**23.03 (<0.001)**	**35.38 (<0.001)**
Entrées	8.66 (0.004)	**17.91 (<0.001)**	2.67 (0.11)
Snacks	**27.86 (<0.001)**	1.28 (0.26)	4.34 (0.038)
Condiments	4.33 (0.038)	4.45 (0.035)	**16.77 (<0.001)**
Beverages	7.71 (0.006)	0.16 (0.70)	1.51 (0.22)

Note: Generalized Linear Models presented, with sex and grade as covariates in all models; $P < .002$ indicates significance after Bonferroni correction applied; Pair refers to matched pairs of schools with and without a salad bar. Pairs were matched based on %racial/ethnic minoritized (above or below 85% minoritized) and the lunchroom environment (distance from the mean Smarter Lunchroom score). N = 21 trays had 100% plate waste (0 kcal consumed) and thus could not be included in analyses examining proportion of the meal energy from each component.

energy. The association between salad bar presence and F&V and lunch energy intake was inconsistent, suggesting that salad bars' influence on F&V and lunch energy intake might vary by school characteristics. In Pair 1, which had the lowest Smarter Lunchroom score (i.e., less optimal lunchroom environment related to behavioral economics environmental strategies promoting healthy meal choices), total lunch energy intake was higher in the salad bar school vs. its comparison (with no differences in vegetable energy). In Pairs 2 and 3 (schools with higher Smarter Lunchroom scores) vegetable energy intake was greater in the salad bar school, with no differences in total energy intake. Perhaps school food environment factors captured by this Smarter Lunchroom assessment (e.g., food placement) optimized vegetable intake, but did not influence overall energy intake in the presence of a salad bar. Although vegetable energy was higher overall in salad bar schools, this difference (+11 kcal) is unlikely to influence children's weight. A prior study with middle and high school students also reported that energy intake was higher in schools with salad bars compared to those without salad bars (yet there were no differences in vegetable intake) (Johnson et al., 2017).

F&V energy intake was unrelated to non-FV energy intake. This is consistent with a prior study examining F&V and total energy intake in Farm to School programming (Bontrager Yoder and Schoeller, 2014). The current study's use of weighed starting portions and validated methods for estimating starting portions of self-serve items (Bean et al., 2018) improved upon this prior report's use of food service directors' serving size estimates (Bontrager Yoder and Schoeller, 2014). Similarly, data from the Fresh Fruit and Vegetable Program also reflected no differences in total energy intake in schools based on program participation (US Department of Agriculture, 2013). Thus, focusing solely on increasing F&V intake might be ineffective in reducing energy intake at school lunch.

Mean energy intake consumed by the students (304 ± 157 kcal [salad bar]; 269 ± 152 kcal [control]) was below the calorie mandate for this age group (550–650 kcal/day over a 5-day average[1]), thus neither the NSLP, nor salad bars, are likely major contributors to excessive caloric intake. These energy levels also might suggest that, if children consumed more of their F&Vs at lunch, there might not be a need for energy displacement, as they benefit from nutrients provided by all components of their NSLP meal. Indeed, within this district, most meals selected met nutrient recommendations, although only 23% of students' meals met total calorie guidelines (Adams et al., 2021). With regards to consumption, only 5% of students' meals met total calorie guidelines (and intake also fell short of calcium, iron, vitamin A, vitamin C, and fiber guidelines). Indeed, on average, over 50% of the energy selected was wasted in the current study. Thus, additional strategies to optimize children's nutrition intake and reduce waste within the NSLP are needed.

This report is limited by its cross-sectional design and limited matching methods due to the homogenous racial/ethnic distribution of schools. Menus and day of the week were matched within school pairs, yet there was only one rating day and lunch per pair; thus data do not capture daily variations in consumption and might not reflect typical intake or generalize across this district.

Although salad bars expose children to a greater variety of F&Vs and foster choice, (Harris et al., 2012) there is no evidence that they displace or reduce energy intake. Future studies should include more schools, multiple assessment days, and detailed school food environment measures to facilitate identification of conditions optimizing the impact of salad bars.

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Author contributions

MKB and HR formulated the research question. MKB, HAR, LMT, and SEM designed the study. MKB and SEM implemented the study procedures. LMT analyzed the data. MKB drafted the initial version of the manuscript. All authors reviewed and contributed substantially to subsequent drafts of the manuscript and approved the final version as submitted.

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