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Improving Student Nutrition through a School Dining Redesign: A Mixed-Methods Evaluation

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Improving Student Nutrition through a School Dining Redesign: A Mixed-Methods Evaluation

By

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ABSTRACT

Improving Student Nutrition through a School Dining Redesign: A Mixed-Methods Evaluation

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Despite the link between school-lunch participation and student health, only half of adolescents with the program in their schools participate on a given day. A multi-pronged school lunch promotion intervention was implemented in middle and high schools in an urban, low-income school district to improve school lunch participation and reduce food waste. This dissertation assesses the impact of the intervention on student and teacher perceptions of school lunch and explores how leadership shaped intervention implementation.

Using student survey data, paper 1 explores the theoretical pathways (perceptions of school-lunch quality and convenience) through which the intervention was expected to increase school-lunch participation and decrease plate waste. We observed modest changes in perceptions of school-lunch quality and no changes in perceptions of school-lunch convenience. Results suggest that additional efforts are needed to improve school-lunch participation and dietary intake.

Paper 2 utilizes teacher survey data to assess the impact of the intervention on teacher perceptions, modeling, and encouragement related to school lunch. Results indicate that the intervention had a modest effect on teacher-reported frequency of eating in the cafeteria with students and on encouraging students to participate in the school lunch program. There was no change, however, in teacher perceptions of or participation in the school lunch program. The paper concludes that improvements in teacher perceptions of school meals may not be needed in order for teachers to promote the school-lunch program to students.

Paper 3 focuses on the implementation of the intervention. Through qualitative interviews, the paper characterizes implementation leadership in the context of the intervention; and contextualizes emergent findings in the existing implementation science literature. Four major themes emerged reflecting the ways in which leaders are perceived to influence implementation effectiveness: (1) leader understanding of the technical and operational details of the intervention; (2) leader ability to develop and communicate intervention plans; (3) leader supervisory oversight over implementation staff and contractors; and (4) leader acknowledgment that ‘innovation’ requires time and stakeholder input —the absence of which can threaten

cohesion and buy in. Implementation leadership functions in a school nutrition context appear similar to those identified in the implementation science literature. Results are the first to illustrate how these leadership dimensions are performed in a school nutrition setting.

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INTRODUCTION

The National School Lunch Program (NSLP) offers a unique opportunity to intervene around youth dietary intake as the program is in roughly 95% of primary and secondary schools in the United States.[1,2] However, both participation and consumption are suboptimal. Though students who participate in the NSLP eat more healthfully at lunch than students who do not,[3,4] only 56% of students with NSLP in their schools participate on a given day, with even lower participation rates in middle and high schools.[5] Further, among students eating school meals, nearly half of selected fruits and vegetables are wasted.[6–8]

The physical and social environments contribute to these two issues.[9–11] The physical dining environment affects satisfaction with school meals[12] and perceptions of food quality,[13] that in turn can influence school-meal participation rates.[14,15] It is unknown, however, if improvements to the cafeteria environment can improve lunch participation and fruit and vegetable intake. Further, youth report that convenience is a driving factor in their food choices.[16] Food sales through vending machines and mobile carts offer promising evidence in improving food convenience,[11,17,18] yet their use in school lunch programs has not yet been tested. Finally, norms set by adults influence youth dietary habits.[9,10] Little is known, however, about the role of teachers in encouraging student participation in the NSLP.

A multi-pronged school meal promotion intervention comprised of 1) cafeteria redesigns; 2) the sale of school lunch through vending machines and mobile carts; and 3) teacher education regarding school meals was developed to address these gaps. This dissertation focuses on three issues that are key to understanding the efficacy and feasibility of this intervention. First, I examine the intervention's impact on school-lunch perceptions and self-reported fruit and vegetable consumption among students. Second, I examine the intervention's impact on teacher perceptions, role modeling, and encouragement of school meals. Third, I explore how leaders can support the implementation of nutrition innovations in a school setting. This research helps fill a gap in the literature on strategies to improve the uptake of the NSLP.

PAPER 1

The impact of a multi-pronged intervention on student perceptions of school lunch

ABSTRACT

Background: School meal programs provide an opportunity to improve student dietary habits. We explore the theoretical pathways (perceptions of school-lunch quality and convenience) through which a school lunch promotion intervention was expected to increase school-lunch participation and decrease plate waste.

Methods: Using a repeated cross-sectional design, surveys (n=12,827) from middle and high school students in 12 intervention and 11 comparison schools were included in the analysis. Logistic and linear regression models were used to investigate change in school-lunch perceptions and lunchtime fruit and vegetable consumption from 2016 (baseline) to 2018 (follow-up). Generalized linear models were used to assess change in daily fruit and vegetable consumption.

Results: Among 8th grade respondents, there was a relative increase in perceptions that school lunch tastes good (0.19; 95% CI: 0.07, 0.31, p<0.01) and that lunch is enough to make them feel full (0.17: 95% CI: 0.04, 0.29, p<0.01) in intervention versus comparison schools. Significant relative increases in fruit (6.2%; 95% CI: 1.0%, 11.5%, p<0.05) and vegetable consumption (6.1%; 95% CI: 1.5%, 10.7%, p<0.01) at lunch were seen in grade 10 only. In grade 9 only, a relative increase in daily fruit intake was seen in intervention schools versus comparison schools (difference-in-change 0.09 cups/day; 95% CI: 0.03, 0.15, p<0.01).

Conclusion: This study provides an important exploration of a conceptual model on perceptions of school-lunch quality and convenience. We observed only modest changes in perceptions of school lunch and fruit and vegetable consumption that were not consistent across all grades, suggesting that additional efforts are needed to improve school-lunch uptake.

INTRODUCTION

Less than one quarter of adolescents in the United States meet national dietary recommendations for fruit and vegetable intake,[19] and poor childhood dietary habits have been linked to adult chronic disease[20,21] and obesity.[20,22] The National School Lunch Program (NSLP), which has been shown to provide healthier meals than those brought from home or purchased elsewhere,[3,23] could improve children's dietary intake. However, while the NSLP has the potential to reach nearly every public-school student in the nation,[24] participation rates are suboptimal. On a given day, only 52% of middle school students and 39% of high school students attending schools with the NSLP participate in the program.[5] Further, plate waste in the NSLP remains high, especially for vegetables,[7,25] while low vegetable consumption is a major contributor to chronic disease.[20,21]

Perceptions of meal quality[14,15,26,27] and time available to eat during the lunch period[9,28,29] are two driving factors that influence school meal participation and consumption. The physical dining space[13,26] and norms set by peers or adults[30] may impact meal perceptions, yet to our knowledge, interventions targeting these factors have not been studied in school cafeteria settings. Further, additional points of sale, such as vending machines and mobile carts, have potential to reduce

school-lunch wait times, yet their efficacy in school-lunch programs remains unknown.

A multi-pronged intervention comprising cafeteria redesign, teacher education about school meals, and school meal sales through vending machines and mobile carts[31] was implemented in middle and high schools in an urban, low-income school district to improve NSLP participation and reduce food waste. A small relative increase in NSLP participation, the primary study outcome, was observed in the intervention schools compared to control schools[32] and plate waste did not improve in intervention schools.[33] In an effort to understand why the innovative intervention was not more impactful, we sought to explore the theoretical pathways through which the intervention was expected to increase participation and decrease plate waste, namely student perceptions of meal quality and convenience. Better understanding the validity of our conceptual model can identify additional targets for intervention and enhance the likelihood that future interventions will achieve greater impacts.

METHODS

Study Design

A repeated cross-sectional, quasi-experimental design was used. Twenty-four schools (12 middle and 12 high schools) in a large, urban school district in California participated in the study from school years 2015-16 (baseline) through 2017-18. Twelve schools (N≈12,900 students in grades 6-12) received the intervention and 12 (N≈11,200 students in grades 6-12) served as comparison schools. Details on study design have been published previously;[31] briefly, 5 schools that had piloted the intervention prior to the study were assigned to the intervention and the remaining 19 schools were randomly assigned, stratifying on school type (middle vs. high) and an index of high vs. low need (based on student eligibility for free or reduced-price meals, percent who identify as White, and academic performance).[31] The intervention was rolled out over a 2-year period with full implementation by fall 2017. This study uses data from student surveys administered in spring of 2016 (baseline) and 2018 (full intervention implementation). The study was approved by the Committee for Protection of Human Subjects at the University of California, Berkeley and by the school district's research office.

Participants

All students in grades 7-10 in 2016 (N≈13,500) and grades 8-10 (N≈10,500) in 2018 were eligible to complete anonymous surveys, administered by teachers in homerooms in spring of 2016 and 2018. Surveys were also administered in spring 2017 but were not included in analyses as not all intervention schools had full implementation that school year.[31] Parent/guardian notices with opt-out slips were sent home with all students prior to student participation in the survey. One comparison high school was dropped from the analysis since they did not complete surveys at baseline.

Intervention and Conceptual Framework

The intervention, which was grounded in principles of behavioral economics and social learning theory,[31] included three components: cafeteria redesign, teacher outreach, and mobile carts and vending machines. As depicted in Figure 1, the intervention was designed to improve student perceptions of school-lunch quality and convenience (proximal outcomes), which were expected

to increase school-lunch participation, reduce plate waste, and ultimately increase fruit and vegetable consumption by students (distal outcomes).

Proximal outcomes of the intervention included student perceptions of lunch quality (satiety, taste, and healthfulness) and convenience (lunch line length). The dining environment has been shown to predict student satisfaction with school meals[12] and perceptions of meal quality.[13] Additional research shows that the same meal served in a school setting is perceived as of lesser quality than when served in a restaurant setting.[13] Therefore, we posited that improving the school cafeteria environment with colorful paint and artwork and modern décor and furniture would improve student perceptions of school lunch. Adult modeling[9,34–36] and encouragement of healthy eating[9,35] has been associated with healthy dietary habits among children. We therefore hypothesized that improvements in teacher modeling and encouragement of school lunch through teacher outreach would improve student perceptions of school lunch. Additionally, offering meals through visually-appealing vending machines and mobile carts could affect perceptions of quality. Mobile carts and vending machines are also promising methods to improve the convenience of food delivery in a school setting[18,37] and we posited that delivering school lunch through vending machines and mobile carts would improve student perceptions of school-lunch convenience.

Distal outcomes of the intervention included school-lunch participation, plate waste, and fruit and vegetable consumption at school and over the entire day. As perceptions of lunch quality are associated with participation in prior studies,[14,15,26] we hypothesized that improvements in perceived lunch quality would lead to improvements in participation. Because students say convenience is a top predictor of the food choices they make,[9] we also hypothesized that increased perceptions of convenience would increase school-lunch participation. As negative perceptions of NSLP food quality are associated with plate waste, we posited that improvements in perceptions of school lunch quality would lead to a decrease in food waste.[38] Positive perceptions of convenience may also reduce plate waste as more time available to eat lunch is associated with less plate waste.[29]

Finally, improvements in perceptions of convenience and school-lunch participation are posited to improve fruit and vegetable consumption. As youth say that fruits and vegetables are time-consuming to eat,[39] improvements in convenience could differentially improve fruit and vegetable consumption. Gains in participation could also differentially improve fruit and vegetable consumption since NSLP lunches tend to have more fruits and vegetables than lunches brought from elsewhere, and students who participate in the NSLP consume more fruits and vegetables than those who do not.[3,23]

Measures

Outcomes were based on student survey data. The variables of interest on the student survey included perceptions of school lunch, lunch-purchasing behavior, and lunchtime fruit and vegetable intake. Perception questions were adapted from the Healthful Eating Active Communities Student Survey.[40] Students were asked if they agreed (5-point Likert scale from 1 =“Strongly Disagree” to 5 =“Strongly Agree”) with the statements: “the school lunch is enough to make me full”, “school lunch tastes good”, “school lunch is healthier than foods I bring from home or off-campus”, and “lunch lines are too long”. These variables were treated as continuous as they were normally distributed.

Lunchtime intake of fruit (not including fruit juice), 100% fruit juice, vegetables (not including fried potatoes), and salad by students was assessed with the question "yesterday at lunch, how much did you eat" with response options "none", "a little", "some", and "a lot". For each of the 4 items, responses were collapsed into binary variables for none or any consumption. Fruit intake is reported as fruit (excluding juice), all fruit (fruit juice and fruit excluding juice combined), and vegetables (vegetables—excluding fried potatoes— and salad combined).

Fruit and vegetable consumption in a typical week was also measured to determine if the intervention influenced overall daily intake. Daily cup equivalents were estimated using the Block Kids 2-17 Screener,[41] which was selected given time and feasibility constraints in the school setting. The screener has been validated against a 24-hour dietary recall, with correlations adjusted for within-subject variance of measures covering different time intervals of 0.53 and 0.60 for vegetables and fruit respectively.[41] For each of the 11 types of fruits and vegetables listed, students were asked "how many days a week do you usually eat it?" (ordinal categorical variable, range 0-7) and "if you eat it, about how much in one day?" (ordinal categorical variable: "a little", "some", and "a lot"). NutritionQuest (Berkeley, CA), the developer of the Block Screener, converted responses to daily cup equivalents of all fruits, fruits (excluding juice), all vegetables, and vegetables (excluding potatoes) consumed based on age and gender. Students who did not identify as male or female were excluded from the Block analysis as the analysis only assigns valid values to those with male or female gender.

To allow for analyses restricted to students who eat the school lunch-- as these are the students for whom we would expect the greatest change-- students were also asked "where do you usually get your lunch on a school day" and "did you eat school lunch yesterday". The first question was used to restrict the sample to those who typically eat the school lunch for school-lunch perception questions. The second question was used to restrict the sample to students who ate school lunch the day of the assessment for dietary intake questions.

Analysis

Surveys were anonymous, which precluded matching student responses over time. Since it is likely that many students participated in the survey both at baseline and follow-up, observations from year to year may not be independent. As within-student dietary intake is highly correlated, and dependence violates the parameters of our statistical models, we conducted stratified analyses by grade, comparing baseline (N=6,502) to follow-up (N=6,325) responses in grades 8, 9, and 10 separately.

Logistic and linear random intercept models with a random effect for school were used to investigate change in school-lunch perceptions and lunchtime fruit and vegetable consumption by intervention and comparison groups from baseline to 2 years follow up. Restricted maximum likelihood estimations were used in the linear models to account for a small number of clusters. Generalized linear models, with a gamma family log link and clustering by school, were used to assess change in daily fruit and vegetable consumption to account for the zero values and non-normal distribution of residuals. In all models, school-level covariates included student enrollment and percent free and reduced price meal eligibility, and student-level covariates included gender and race/ethnicity.

RESULTS

Among all students eligible for the survey, overall response rates for baseline and follow-up combined were 65% and 68% for intervention and comparison schools respectively. Baseline and follow up response rates were 66% and 63% for intervention and 69% and 67% for control schools respectively. Significant differences in response rates were seen between control and intervention schools at baseline ($p<0.01$), follow up ($p<0.001$), and overall ($p<0.001$). The final sample of students— comprising of those with complete demographic data in grades 8, 9 and 10— includes 3,551 from intervention schools and 2,951 from comparison schools at baseline and 3,257 and 3,068 from intervention and comparison schools respectively at follow-up (N=12,827 in total). The sample size varies slightly by survey question due to missing data. Table 1 presents demographic characteristics of the included survey respondents at baseline and follow-up.

At baseline among all students, 11% agreed that school lunches were filling, 5% that school lunches tasted good, 10% that school lunches were healthy, and 47% that the lines were too long. Table 2 presents mean Likert-scale scores for school-lunch perception outcomes. There was a significant between-group difference in change in perceptions of taste and feeling full among 8th grade students only. Perceptions that school lunch tasted good (0.19: 95% CI: 0.07, 0.31, $p<0.01$) and that lunch is enough to make them feel full (0.17: 95% CI: 0.04, 0.29, $p<0.01$) significantly increased in intervention versus comparison schools. No significant changes were seen in perceptions healthfulness of school lunch compared to other lunch options, or of line length, for any grade. When restricting the sample to students who typically ate school lunch, a relative increase in perceptions of fullness was seen for grade 10 only, (difference-in-change 0.37; 95% CI: 0.07, 0.67, $p<0.05$) and no changes in perceptions of school lunch were seen in grades 8 and 9 (data not shown).

Tables 3 and 4 present student-reported lunchtime and daily fruit and vegetable consumption, respectively. Significant relative increases in lunchtime consumption of all fruit (difference-in-change 6.2%; 95% CI: 1.0%, 11.5%, $p<0.05$), and vegetables excluding fried potatoes (difference-in-change 6.1%; 95% CI: 1.5%, 10.7%, $p<0.01$) were seen in grade 10 only. No changes were seen when restricting to those who ate school lunch the day of the assessment (data not shown).

For weekly fruit and vegetable intake, a relative increase in fruit consumption was seen in grade 9 only (difference-in-change 0.09 cups per day; 95% CI: 0.03, 0.15, $p<0.01$). When restricting to those who ate school lunch the day of the assessment, relative decreases in all vegetables (difference-in-change -0.32; 95% CI: -0.48, -0.16, $p<0.001$) and vegetables excluding potatoes (difference-in-change -0.29; 95% CI: -0.46, -0.12, $p=0.001$) were seen for grade 10 students in intervention vs. comparison schools. No other changes were seen in the restricted sample (data not shown).

DISCUSSION

This study provides an important exploration of a conceptual model on perceptions of school-lunch quality and convenience and fruit and vegetable intake. Results suggest that the intervention was modestly effective in improving perceptions of lunch quality among students in grade 8 but ineffective in improving perceptions of convenience among students in any grade,

the hypothesized mechanisms of change. The results provide insight into why relative increases were seen in lunch participation[32] and student-reported fruit and vegetable consumption while plate waste did not improve[33] over the course of the intervention.

Though perceptions of taste and feeling full marginally improved for 8th grade students, students had poor perceptions of school lunch across all grades at baseline, with most students not agreeing that lunch was healthy or tasted good. Our findings on student-reported meal perceptions are slightly lower than other studies exploring perceptions of meal quality during similar years. In a survey of middle school students, Smith et al. found that roughly half of students agreed that school meals tasted good or were healthy.[15] In another study on middle school student perceptions, Kjosen et al. found that the mean agreement score for school meal satisfaction (a composite of multiple quality attributes, including taste and appearance) was a 3, or "Agree a Little", on a 4-Point Likert scale.[42] Other studies also indicate that students want higher-quality school meals.[14,15,43] Our study suggests that simply changing how meals are served is insufficient to improve perceptions; changes in the quality of school meals may be required. In our study, no changes were made to the meals.

The intervention did not appear to have an effect on perceptions of school-lunch convenience as perceptions of lunch lines remained unchanged in both intervention and comparison schools. Further, student agreement that lunch lines were too long remained high despite the additions of a vending machine and mobile cart at each intervention school. As we documented previously, all points of sale (regular lunch line, vending machine, and mobile carts) were only in operation together 27% of the days during the intervention and on days when the additional points of sale were in operation, only 3% of meals were sold from vending machines and 15% from carts on average.[32] The vast majority of students still used the regular lunch line. Thus the vending machines and mobile carts did not appear to do as much as expected to expand the number of points of access, which was not sufficient to alter perceptions of line length. Qualitative interviews with staff implementing the intervention suggest that the operational inconsistency of the mobile carts and vending machines, paired with regulatory constraints that limited location options, may have contributed to low use of the additional points of sale. Future studies are needed to explore how to market and operate additional points of sale to improve student uptake of school meals.

The intervention appeared to improve lunchtime fruit and vegetable consumption for 10th grade students only. However, the association disappears for fruits and vegetables when restricting to those who ate school lunch the day of the assessment, the very students among whom we would expect to see an increase. Further, in this restricted sample for grade 10, the intervention group saw decreases in daily consumption of vegetables relative to the comparison group. In addition, findings from objective plate waste show relative increases in fruit and vegetable waste in intervention schools versus comparison schools.[33] These discrepancies suggest that the intervention does not increase fruit and vegetable intake.

Findings on perceptions of lunch quality and convenience add to our understanding of why school lunch participation, plate waste, and fruit and vegetable consumption (our distal outcomes) did not markedly improve. It is possible that though some meal quality indicators improved slightly, the inconsistencies across grades and the small magnitude of change did not translate into improvements in overall school meal participation or plate waste. Further, students

still did not have enough time to eat, as evidenced by no improvements in perceptions of lunch line length, and thus plate waste and fruit and vegetable consumption did not improve.

This study has several limitations. As only anonymous data were collected, we were unable to link individual student observations at baseline and follow up, limiting our ability to include all students in the analyses and utilize a longitudinal design. Further, the full intervention was only in place for one school year instead of two, as originally planned. The delayed roll-out of the intervention, accompanied by the inconsistent operation of the vending machines and mobile carts, reduced the intended intervention dose and may have contributed to null findings. Finally, as lunchtime fruit and vegetable intake was assessed with only a semi-quantitative measure, and as the Block Screener demonstrates moderate validity[41] for daily fruit and vegetable consumption measurement, the data may not reflect objective consumption.

We hypothesized that an intervention involving cafeteria redesigns, teacher outreach, and mobile carts and vending machines would increase student perceptions of lunch quality and convenience by middle and high school students, which in turn would result in improved student participation and intake of school lunch. We observed only modest changes in perceptions of school meals that were not consistent across grades, suggesting that additional efforts are needed to impact changes in student uptake of school meals. Given that virtually all children in the U.S. have access to school meals[1,2]and that school meals are healthier than what students typically consume elsewhere,[3,23] it is critical to identify additional ways to improve school meal uptake by students.

Figure 1.1 Conceptual Framework

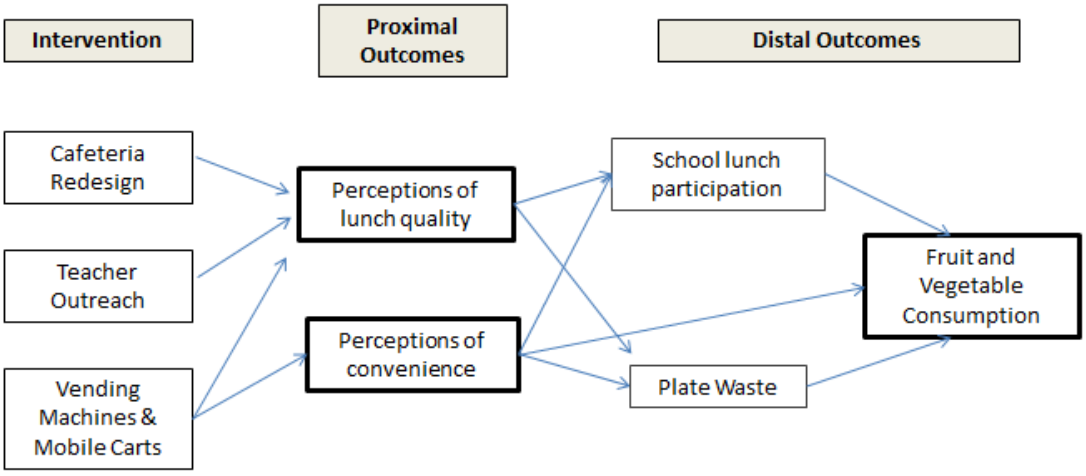


Table 1.1 Demographic Characteristics of Survey Sample

	Surveys from Intervention Schools[a,b]	Surveys from Comparison Schools[a,b]	P-value[c]
Race/Ethnicity, N (%)			**<.001**
African American	264 (4%)	222 (4%)	
Asian	3,548 (52%)	2,822 (47%)	
Latino	1,680 (25%)	1,130 (19%)	
White	426 (6%)	926 (15%)	
Other[e]	890 (13%)	919 (15%)	
Gender, N (%)			**<.001**
Female	3,153 (46%)	3,206 (53%)	
Male	3,525 (52%)	2,664 (44%)	
Other[f]	130 (2%)	149 (2%)	
Grade 8, N (%)	1,969 (29%)	2,085 (35%)	**<.001[d]**
Ate school lunch yesterday	456 (24%)	456 (22%)	0.377
Typically eat school lunch	413 (22%)	429 (22%)	0.808
Grade 9, N (%)	2,534 (37%)	1,883 (31%)	**<.001[d]**
Ate school lunch yesterday	615 (25%)	267 (14%)	**<.001**
Typically eat school lunch	572 (24%)	260 (15%)	**<.001**
Grade 10, N (%)	2,305 (34%)	2,051 (34%)	**<.001[d]**
Ate school lunch yesterday	602 (27%)	390 (19%)	**<.001**
Typically eat school lunch	572 (26%)	358 (18%)	**<.001**

[a] N's include respondents with complete race/ethnicity, grade, and gender data.
[b] While stratified (within-grade) analyses compared unique groups of students, some students are counted in both grades 8 and 10, reflecting the longitudinal nature of the study. Surveys are anonymous.
[c] P-values based on Chi^2 tests.
[d] P-value for differences in proportion in grades 8, 9 and 10 for intervention vs. comparison schools.
[e] Includes respondents who identify as multiple or other races/ethnicities or declined to state their race/ethnicity.
[f] Includes respondents who identify as other gender or declined to state their gender.

Table 1.2 Student-Reported School Lunch Perceptions, Baseline (2016; N=2088 in grade 8, 2237 in grade 9, 2177 in grade 10) to Follow Up (2018; N=1966 in grade 8, 2180 in grade 9, 2179 in grade 10)[a]

	Intervention Schools			Comparison Schools			Between-Group Difference in Change[b] 95% CI
School lunch[c]:	**Baseline** Mean ± SE	**Follow Up** Mean ± SE	**Difference** Mean 95% CI	**Baseline** Mean ± SE	**Follow Up** Mean ± SE	**Difference** Mean 95% CI	
Enough to feel full							
grade 8	2.39 ±0.05	2.43 ±0.05	0.04 -0.05, 0.14	2.44 ±0.04	2.32 ±0.05	-0.12** -0.21, -0.04	0.17** 0.04, 0.29
grade 9	2.55 ±0.06	2.61 ±0.06	0.06 -0.01, 0.14	2.41 ±0.07	2.43 ±0.07	0.02 -0.06, 0.11	0.04 -0.08, 0.16
grade 10	2.51 ±0.04	2.55 ±0.04	0.04 -0.04, 0.12	2.47 ±0.04	2.39 ±0.04	-0.08 -0.16, 0.01	0.12 0.00, 0.23
Tastes good							
grade 8	2.01 ±0.06	2.01 ±0.06	0.00 -0.08, 0.09	2.08 ±0.05	1.89 ±0.06	-0.18*** -0.27, -0.10	0.19** 0.07, 0.31
grade 9	2.31 ±0.07	2.34 ±0.07	0.02 -0.05, 0.10	2.04 ±0.08	2.09 ±0.08	0.05 -0.04, 0.13	-0.02 -0.14, 0.09
grade 10	2.34 ±0.06	2.34 ±0.06	0.00 -0.08, 0.08	2.18 ±0.07	2.20 ±0.07	0.02 -0.07, 0.10	-0.02 -0.13, 0.10
Healthier than foods I bring from home or off-campus							
grade 8	2.28 ±0.04	2.25 ±0.04	-0.03 -0.12, 0.06	2.29 ±0.04	2.17 ±0.04	-0.12** -0.21, -0.03	0.09 -0.03, 0.22
grade 9	2.49 ±0.04	2.51 ±0.04	0.03 -0.05, 0.10	2.31 ±0.05	2.38 ±0.05	0.07 -0.02, 0.16	-0.05 -0.17, 0.07
grade 10	2.50 ±0.04	2.53 ±0.04	0.03 -0.05, 0.11	2.33 ±0.05	2.38 ±0.05	0.05 -0.04, 0.13	-0.02 -0.13, 0.10
Lines are too long							
grade 8	3.62 ±0.10	3.67 ±0.10	0.05 -0.04, 0.14	3.60 ±0.09	3.60 ±0.09	0.00 -0.08, 0.09	0.05 -0.08, 0.17
grade 9	3.49 ±0.15	3.39 ±0.15	-0.10* -0.17, -0.02	3.28 ±0.18	3.21 ±0.18	-0.08 -0.16, 0.01	-0.02 -0.14, 0.09
grade 10	3.55 ±0.18	3.49 ±0.18	-0.06 -0.14, 0.01	3.25 ±0.21	3.12 ±0.21	-0.13** -0.21, -0.05	0.07 -0.05, 0.18

Values based on linear random intercept models with school as a random effect and adjusting for school-level enrollment and percent free and reduced price meal eligibility and student-level gender and race and ethnicity.

[a] N's include respondents with complete race/ethnicity, grade, and gender data. N's vary slightly by question due to missingness. Missingness range 1-2%.

[b] Difference in change from baseline to follow up in intervention schools compared to comparison schools.

[c] 5-point Likert scale from 1-5 ("Strongly Disagree" to "Strongly Agree")

* $p<0.05$ ** $p\leq0.01$ *** $p=0.01$

Table 1.3 Student-Reported Lunchtime Fruit and Vegetable Consumption "Yesterday", Baseline (2016; N=2088 in grade 8, 2237 in grade 9, 2177 in grade 10) to Follow Up (2018; N=1966 in grade 8, 2180 in grade 9, 2179 in grade 10)[a]

	Intervention Schools			**Comparison Schools**			**Between-Group Difference in Change**
% Agree	**Baseline** Mean ± SE	**Follow Up** Mean ± SE	**Difference** Mean 95% CI	**Baseline** Mean ± SE	**Follow Up** Mean ± SE	**Difference** Mean 95% CI	
Ate fruit at lunch yesterday (excluding fruit juice)							
grade 8	56.9% ±3.5%	56.6% ±3.8%	-0.3% -7.1%, 6.4%	61.4% ±3.0%	56.4% ±3.0%	-4.9% -10.6%, 0.8%	4.6% -4.4%, 13.6%
grade 9	56.7% ±2.8%	52.8% ±3.4%	-3.9% -10.0%, 2.1%	57.3% ±2.7%	54.7% ±3.1%	-2.7%* -5.0%, -0.3%	-1.3% -7.7%, 5.2%
grade 10	60.5% ±3.2%	61.3% ±3.2%	0.8% -3.7%, 5.3%	56.5% ±3.3%	52.5% ±4.4%	-4.0%* -7.8%, -0.3%	4.8% -1.0%, 10.6%
Ate fruit at lunch yesterday (including fruit juice)							
grade 8	59.9% ±3.8%	59.1% ±3.6%	-0.8% -7.4%, 5.8%	65.1% ±2.6%	58.3% ±2.8%	-6.8%* -12.8%, -0.7%	6.0% -3.2%, 15.2%
grade 9	60.2% ±2.4%	57.0% ±2.9%	-3.2% -8.0%, 1.7%	61.6% ±2.6%	57.0% ±2.7%	-4.7%*** -7.5%, -1.9%	1.5% -4.0%, 7.0%
grade 10	62.3% ±2.8%	63.3 ±2.9%	1.0% -3.7%, 5.6%	61.8% ±3.1%	56.6% ±4.0%	-5.3%*** -8.0%, 2.5%	6.2%* 1.0%, 11.5%
Ate vegetables at lunch yesterday (excluding fried potatoes)							
grade 8	40.9% ±3.6%	45.6% ±3.9%	4.7% -0.3%, 9.7%	47.5% 3.8%	46.1% 3.4%	-1.4% -5.6%, 2.8%	6.1% -0.5%, 12.6%
grade 9	47.1% ±3.2%	49.3% ±2.1%	2.3% -4.0%, 8.5%	49.5% ±3.2%	49.2% ±2.4%	-0.3% -7.3%, 6.7%	2.5% -6.8%, 11.9%
grade 10	53.1% ±2.1%	56.0% ±2.4%	2.9% -0.9%, 6.6%	50.6% ±2.0%	47.3% ±1.8%	-3.3%* -6.3%, 0.2%	6.1%** 1.5%, 10.7%

Values based on logistic random intercept models with school as a random effect and adjusting for school-level free or reduced price meal eligibility and enrollment and student-level gender and race/ethnicity.

[a] N's include respondents with complete race/ethnicity, grade, and gender data. N's vary slightly by question due to missingness. Missingness range 1-3%.

*p<0.05 **p<0.01 ***p≤0.001

Table 1.4. Student-Reported Weekly Fruit and Vegetable Consumption (Cups/Day), Baseline (2016; N=2040 in grade 8, 2192 in grade 9, 2140 in grade 10) to Follow Up (2018; N=1904 in grade 8, 2129 in grade 9, 2132 in grade 10)[a]

	Intervention Schools			**Comparison Schools**			**Between-Group Difference in Change**[b] 95% CI
Cups/Day	**Baseline** Mean ± SE	**Follow Up** Mean ± SE	**Difference** Mean 95% CI	**Baseline** Mean ± SE	**Follow Up** Mean ± SE	**Difference** Mean 95% CI	
Fruit (excluding fruit juice)							
grade 8	1.08 ±0.03	1.11 ±0.04	0.03 -0.09, 0.15	1.00 ±0.02	0.97 ±0.04	-0.03 -0.10, 0.04	0.06 -0.08, 0.19
grade 9	0.96 ±0.05	0.90 ±0.04	-0.06 -0.12, 0.00	1.07 ±0.05	0.94 ±0.04	-0.13*** -0.18, -0.08	0.07 -0.01, 0.14
grade 10	0.88 ±0.03	0.89 ±0.04	0.00 -0.10, 0.11	0.98 ±0.03	0.98 ±0.02	0.00 -0.07, 0.08	0.00 -0.14, 0.15
All fruit							
grade 8	1.39 ±0.04	1.42 ±0.06	0.04 -0.12, 0.19	1.36 ±0.03	1.30 ±0.04	-0.06 -0.13, 0.02	0.07 -0.06, 0.20
grade 9	1.25 ±0.05	1.17 ±0.03	-0.08** -0.13, -0.03	1.39 ±0.05	1.18 ±0.03	-0.21*** -0.27, -0.15	0.09** 0.03, 0.15
grade 10	1.17 ±0.03	1.17 ±0.04	0.00 -0.09 0.09	1.29 ±0.04	1.24 ±0.03	-0.05 -0.14, 0.03	0.04 -0.06, 0.14
Vegetables (excluding potatoes)							
grade 8	0.70 ±0.02	0.74 ±0.04	0.04 -0.02, 0.10	0.66 ±0.03	0.68 ±0.03	0.02 -0.04, 0.07	0.02 -0.09, 0.14
grade 9	0.66 ±0.03	0.65 ±0.03	-0.01 -0.05, 0.03	0.70 ±0.04	0.67 ±0.03	-0.03 -0.12, 0.05	0.03 -0.11, 0.18
grade 10	0.73 ±0.04	0.77 ±0.03	0.04 -0.06, 0.14	0.72 ±0.02	0.79 ±0.03	0.07* 0.01, 0.13	-0.04 -0.19, 0.11
All vegetables							
grade 8	0.99 ±0.02	1.0 ±0.04	0.01 -0.07, 0.09	0.93 ±0.04	0.95 ±0.04	0.02 -0.08, 0.12	-0.01 -0.14, 0.12
grade 9	0.90 ±0.03	0.88 ±0.03	-0.02 -0.07, 0.02	0.97 ±0.06	0.94 ±0.04	-0.04 -0.17, 0.10	0.02 -0.14, 0.17
grade 10	0.95 ±0.04	0.99 ±0.03	0.04 -0.07, 0.16	0.97 ±0.03	1.05 ±0.04	0.07 -0.01, 0.15	-0.03 -0.16, 0.11

Values based on generalized linear models with a Gamma family log link, clustering by school, and adjusting for school-level free or reduced price meal eligibility and enrollment and student-level gender and race/ethnicity.

[a] N's include respondents with complete race/ethnicity and grade data and those identifying as male or female gender. N's vary slightly by question due to missingness. Missingness <1%.

[b] Relative percent change from baseline to follow up in mean cups/day in intervention schools compared to comparison schools.

* p<.05 **p<0.01 ***p≤0.001

PAPER 2

Teachers as school lunch role models: the impact of a multi-pronged intervention

ABSTRACT

Background: Teachers often have negative perceptions of the school-lunch program making it unlikely they would encourage students to participate. This study explores the impact of a school-meal promotion intervention on teacher perceptions, modeling, and encouragement related to school lunch.

Methods: This repeated cross-sectional study used data from teacher (N=1,089) and student (N=11,292) surveys from 12 intervention and 11 comparison schools at baseline (spring 2016) and at 2-year follow-up (spring 2018). Linear and logistic mixed effects models assessed difference in change in teacher perceptions of school meals and student perceptions of teacher encouragement to eat school lunch. Generalized linear models assessed change over time in frequency of teachers eating school lunch, eating in the cafeteria with students, and encouraging students to eat the school lunch.

Results: A relative increase in teacher-reported frequency of eating with students in the cafeteria was seen in intervention schools (difference-in-change 1.46 times per month; 95% CI: 0.36, 2.55, $p< 0.01$). Students at intervention schools had a relative increase in agreement that adults at their schools encouraged them to eat school lunch (difference-in-change 0.13; 95% CI: 0.05, 0.21, $p=0.001$). No between-group differences were seen in teachers' perceptions of school meals or participation in school meals.

Conclusion: The teacher outreach intervention did not impact teacher perceptions of school meals or teacher participation in the school-lunch program. The intervention, however, did appear to have a modest effect on teacher-reported frequency of eating in the cafeteria with students and on encouragement of student participation in the school-meal program. Results suggest that teacher perceptions of school meals do not necessarily need to be improved in order for teachers to promote the school-lunch program to students.

INTRODUCTION

Childhood obesity remains an urgent public health issue.[44] Although a healthy diet during childhood is critical for preventing adult obesity and chronic disease,[21,22,45] the majority of youth in the United States do not meet the Dietary Guidelines for Americans.[19] Schools offer a unique opportunity to intervene to improve youth dietary intake; the National School Lunch Program (NSLP) is in the vast majority of primary and secondary schools and is accessible to students of all socioeconomic backgrounds.[1,2] While NSLP meals are usually the healthiest lunch option for students,[3,4,23] lunch participation remains relatively low with approximately half of students participating on a given day.[5] There are many approaches to increasing student participation but few have focused on leveraging the social influence of adults.

Adults can influence youth dietary intake through both modeling and encouragement.[9,34–36] Youth who see their parents or other adults eating a healthy diet are more likely to consume healthy foods themselves.[9,34–36] Similarly, youth whose parents encourage them to eat fruits and vegetables consume more fruits and vegetables than youth whose parents do not encourage this behavior.[9,35] It is not clear, however, if these adult influences apply to school lunch: particularly if teachers can positively influence youth participation in the NSLP. While a qualitative study found that youth believe they would eat healthier at school if teachers encouraged them to do so,[9] it remains unknown if teachers can influence youth dietary intake.

Teachers have historically had negative perceptions of the school-lunch program,[46] making it unlikely they would encourage students to participate. However, the 2010 Healthy, Hunger-Free Kids Act (HHFKA) made school meals healthier,[47] and this change may be a leverage point for improving teacher perceptions. It is important to understand if teacher perceptions can be shifted, and in turn, improve teacher modeling behaviors – such as eating school lunch and eating with students in the cafeteria – and increase teachers' encouragement of student participation in school lunch. This study explores the impact of a school-lunch promotion intervention on teacher perceptions, modeling, and encouragement related to school lunch.

METHODS

Study Design

This repeated cross-sectional, quasi-experimental study is part of a larger multi-pronged school-lunch promotion intervention conducted in an urban school district in California over 3 school years (2015-16 through 2017-18).[31] Twenty-four middle and high schools participated in the parent study, 12 of which received an intervention and 12 of which served as comparison schools. The intervention, developed from a partnership between the school district, a local design firm, and University of California Cooperative Extension, aimed to improve the school dining experience for students and staff. The intervention involved a cafeteria redesign, school-meal sales through vending machines and mobile carts, and outreach to teachers to inform them about school meals.[31] The present study uses teacher and student survey data from spring 2016 (baseline) and spring 2018 (follow-up) to examine changes in teachers' perceptions and behaviors related to school lunch. The study received approval by the University of California, Berkeley Committee for Protection of Human Subjects and the school district.

Participants

All teachers from the 24 school sites (N≈700 in intervention and N≈600 in comparison schools) were invited to take part in an anonymous survey in spring 2016, 2017, and 2018. Researchers delivered paper surveys to a point person at each school who was responsible for survey distribution and collection. Teachers were eligible for a gift card raffle each year of survey administration. Surveys from 2017 were not included in analyses as the intervention was not fully implemented that school year.[31] A complete case analysis was used; schools with less than 4 teacher responses at baseline or follow-up were dropped from the analysis. Three intervention schools (1 middle and 2 high) and 2 comparison high schools were excluded from the final

teacher survey sample due to low response. The final teacher survey sample included data from 9 intervention and 10 comparison schools.

As part of the larger intervention,[31] students from the 24 schools were also invited to participate in an anonymous survey. A parent notice with an opt-out slip was sent home with each student. School staff administered surveys in homeroom classes. All 7th-10th grade students (N≈13,500) in spring 2016 and 2017 and all 8th-10th grade students (N≈10,500) in spring 2018 were eligible to complete the survey. Only surveys from baseline and follow-up were included in the analysis. One comparison high school was dropped from analysis as they did not complete surveys at baseline. The final sample included students from 12 intervention and 11 comparison schools.

Conceptual Framework

The teacher outreach intervention was informed by Social Learning Theory,[48] whereby teachers promote a change in student behavior through modeling the desired behavior.[31] Figure 1 outlines the pathways posited to change teacher perceptions and behavior, and ultimately student behavior. We expected that outreach to teachers about the school-lunch program would improve teacher perceptions of school meals and increase their verbal promotion of the program to students. While not specific targets of the intervention, we posited two additional pathways that could occur as a result of improved perceptions: (1) increased visibility of teachers in the cafeteria through teachers eating their lunch with students; and (2) increased teacher school-meal participation. While this framework hypothesizes that the distal effects of outreach to teachers is increased student participation in school lunch, the intent of this paper is to explore the impact of the intervention on proximal and intermediate outcomes.

Intervention Description

Prior to this intervention, the school district made efforts to improve their school-meals. Using money raised through local bonds, they changed their meal provider in 2013 to an innovative company providing "kid-inspired chef crafted" meals, in an effort to improve school-meal quality. Further, they banned all competitive food sales. The teacher outreach component of the intervention was designed to highlight both the school-meal changes made prior to the intervention as well as the present intervention's improvements to the cafeteria environment. The teacher intervention included: staff meeting presentations about the school-lunch program and its importance for student health and achievement; video screenings that showcased school meals and redesigned cafeterias; school-lunch menu-item taste tests; nine newsletters about school-lunch topics (such as school menu offerings, updates about the intervention, the importance of meals for student health and achievement, and ways to encourage student participation in the lunch program); and a teacher resource website with information about the school-lunch program and classroom activities aligned with a variety of school academic subjects to promote learning about school-meals. For the average intervention school, taste tests were offered at one staff meeting and at least eight times in the cafeteria or break room. The average tasting reached 49 teachers. The outreach videos were promoted through emails to all intervention teachers and shown at school-wide screenings or staff meetings. Overall, the videos had over 200 views.

Measures

Teacher Survey

The variables of interest from the anonymous teacher survey include self-report data on perceptions of school lunch, lunchtime eating behaviors, and encouragement of students to eat school lunch. Teachers were asked if they agreed, on a 4-point scale from strongly disagree (1) to strongly agree (4) (with a 5th response option of "NA/unsure"), that "school meals taste good", "school meals are healthy", and "students think school meals are healthy". "NA/unsure" responses were dropped. Responses were collapsed into either strongly agree/agree or strongly disagree/disagree and converted to a binary variable. Teachers were also asked "this year, how often did you eat in the cafeteria with students", "this year, how often did you encourage your students to eat the school lunch", and "this year, how often did you eat school lunch?" These assessments had 5 response options with varied time intervals and were converted to average times per month.

Student Survey

One question from the anonymous student survey was included in the analysis to assess student perceptions of adult encouragement to eat school lunch. Students were asked to rate the degree to which "adults at school encourage me to eat school lunch" using a 5-point Likert scale with response options ranging from strongly disagree (1) to strongly agree (5).

Analysis

To determine if change, from baseline to follow-up, in teachers' perceptions of school meals differed between comparison and intervention groups, logistic mixed effects models with a random effect for school (to adjust for clustering), a group-by-year interaction, and robust standard errors were used. To compare between-group changes in frequency of teachers eating in the school cafeteria, encouraging students to eat, and eating school lunch, generalized linear models with a Gamma family log link (similarly clustering by school) were used to account for right skewness due to a large proportion of zero values, and the count nature of the data. All models were adjusted for school-level free and reduced price meal eligibility: a proxy for student socioeconomic status.

For the student survey question assessing teacher encouragement to eat the school lunch, a linear mixed effects model with a random effect for school and a group-by-year interaction term was used to assess difference in change between comparison and intervention groups. Restricted maximum likelihood estimations were used to account for the small number of clusters. The variable was treated as continuous as responses were normally distributed. School-level covariates included free and reduced price meal eligibility and enrollment and student-level covariates included race/ethnicity, school type (middle and high school), and gender. Grades 7, 9, and 10 at baseline and grades 8 and 10 at follow-up were included in the analysis so as not to violate assumptions of independence in our statistical models.

RESULTS

No statistically significant differences were seen between intervention and comparison schools in number of teachers, response rates, or number of teacher survey responses included in the final analytic sample (Table 1). The final analytic sample included 556 teacher surveys from 2016 and 533 from 2018. Among all students eligible for the survey, significant differences in response rates were seen for intervention and comparison schools (64% vs. 68% $p<0.001$). Baseline characteristics from 2016 are reported in Table 2. No significant school-level differences were seen at baseline. Significant differences in student-level race/ethnicity were seen between student survey respondents in intervention and comparison schools. A total of 6,840 student surveys from 2016 and 4,452 surveys from 2018 were included in the analysis.

At baseline, in intervention and comparison schools combined, 86% (n=464) of teachers reported never eating lunch in the cafeteria with students, 72% (n=398) reported never eating school lunch, and 62% (n=330) reported encouraging students to eat school lunch 1 time a month or less. Further, at baseline, 68% (n=298) of teachers agreed that school meals are healthy, 45% (n=166) agreed that school meals taste good, and 23% (n=102) agreed that students think school meals taste good. At baseline, 17% (n=1,014) of students agreed that adults at school encourage them to eat school lunch.

At follow-up, 14% (n=30) of teachers in intervention schools reported receiving intervention materials 2.5 times per month or more in the prior year, approximately 58% (n=127) reported receiving materials 1 time a month or less, and 29% (n=63) reported never receiving materials.

Table 3 reports the differences in change in frequency of teacher behavior between intervention and comparison schools from baseline (2016) to follow up (2018). A significant decrease in teacher-reported frequency (number of times per month) of eating with students in the cafeteria was seen in the comparison schools while the frequency remained the same in the intervention schools (difference-in-change 1.46 times/mo; 95% CI: 0.36, 2.55, $p< 0.01$). There was no difference in teacher-reported frequency of eating school lunch or encouraging students to eat the school lunch. Compared to their peers at comparison schools, however, students at intervention schools had a relative increase in agreement that adults at their schools encouraged them to eat school lunch (difference-in-change 0.13; 95% CI: 0.05, 0.21, $p=0.001$).

There were no between-group differences from baseline to follow-up in odds of agreeing that school meals are healthy, (OR 0.90; 95% CI: 0.48, 1.68), taste good (OR 1.37, 95% CI: 0.81, 2.30), or that students think school meals taste good (OR 0.86, 95% CI: 0.44, 1.67). In the overall teacher survey sample (baseline and follow-up combined), those who agreed that school meals tasted good and were healthy had a significantly higher frequency of eating school meals than those who disagreed (mean difference 0.91; 95% CI: 0.48, 1.35, and 1.01; 95% CI: 0.53, 1.50 meals per month respectively, $p< 0.001$).

Results from analyses limited to teachers in intervention schools who reported high exposure to the intervention (>2.5 intervention materials per month) were similar to analyses including all participants with one exception: teacher encouragement of student lunch participation. In the restricted sample, there was a significant increase in frequency of teacher encouragement in intervention schools relative to comparison schools (difference-in-change 0.77; 95% CI: 0.27, 1.28, $p< 0.01$).

DISCUSSION

This study is the first to examine both teacher perceptions and behaviors related to school lunch. The intervention appeared to have a modest effect on teacher-reported frequency of eating in the cafeteria with students and on encouragement of student participation in the school-lunch program. The teacher outreach intervention, however, did not impact teacher perceptions of school meals or teacher school-lunch participation.

The intervention was designed in part to improve teacher perceptions of school meals which would in turn increase teacher encouragement of students to eat school lunch and improve modeling behaviors (i.e. eating lunch in the cafeteria with students and eating school lunch). We did not see changes in teacher perceptions, the first component of our conceptual model. The majority of teachers at both baseline and follow-up perceived school lunches to be healthy. This is encouraging, as since the HHFKA went into effect school meals are often the most nutritious option for students.[23] Teacher perceptions of taste, however, were low in all schools at baseline and remained so at follow-up. Anecdotally, in speaking to implementation staff in the present study, teachers often mentioned that their negative views about school meals stem from previous experiences with the meal program. Despite recent improvements to school-meal quality, the meals remained "reheat and serve" style, with plastic coverings, which have been the source of complaints in prior studies.[49] Despite the outreach to teachers which included school-lunch taste tests, the unfavorable taste perceptions of teachers did not change. Lack of change may indicate that the taste of the meals themselves, a component not addressed by the HHFKA, nor by this intervention, needs to be improved in order to see improved teacher perceptions.

Though school-lunch perceptions did not change, the intervention appears to influence teacher encouragement of student lunch participation. Students in intervention schools reported an increase in teachers encouraging them to eat school lunch. While teachers' own report of encouraging students to eat school meals did not increase in the overall sample, teachers receiving >2.5 intervention materials per month did report higher relative levels of encouraging students to eat the school lunch post-intervention. This suggests that the teacher outreach intervention may have succeeded in increasing encouragement for those with high levels of exposure. This may be because teachers with high intervention exposure improved their understanding of the importance of school meals for students. Staff meeting presentations and many of the newsletters included information about the value of the school-lunch program to student achievement, health, and equity. Teachers may have increased their encouragement to students, realizing that school-meals may be the best meal option available to their students. Anecdotal reports from intervention staff showed that teachers were most engaged when staff presented information about the "big picture" of schools meals: connecting school meals with student achievement and student health (data not shown). Though teachers' perceptions of the healthfulness and taste of meals may not have changed, they may have seen the value for students in other ways.

We did see significant increases in one of the two teacher modeling behaviors described in the conceptual model. Teachers in intervention schools reported a relative increase in frequency of eating with students in the cafeteria. This finding could also explain the increase in students reporting that teachers encouraged them to eat school lunch. If, as posited above, the intervention enhances teachers' value for school meals (which we did not test), teachers may increase their visibility in the cafeteria to encourage student participation. While the literature on this topic is

sparse, a 1980 study by Perkins et al. suggests that teachers eating lunch with students is an important factor in elementary student participation.[50] They found that negative teacher attitudes towards eating lunch with students is associated with student non-participation in the program, pointing to the potential viability of the conceptual link between teacher modeling and student meal participation.

Given that teacher perceptions of school meals did not change, it is not surprising that their self-reported frequency of eating school lunch also did not increase. Our prior study measuring objective changes in teacher and staff participation found a slight, yet significant, relative decrease in meal participation in intervention schools (3.0% at baseline and 1.7% at follow-up) relative to comparison schools (1.9% at baseline and 1.1% at follow-up).[32] A potential driver of teacher participation is the taste of the meals themselves. While teachers' perceptions of the taste of school meals did not change, it is possible that teachers' expectations for the meals were raised by the intervention, and tasting the school meals did not meet their higher expectations. Teachers who agreed that school meals tasted good had a significantly higher frequency of self-reported school lunch participation than those who disagreed. This association between perceptions of taste and school-meal participation is consistent with other studies looking at student populations.[14,26,51] Findings from our study suggest that an outreach intervention alone is not sufficient in improving teacher school-lunch participation; the taste of the meals may need to be addressed as well. Our larger study found a small relative increase in student meal participation.[32] This suggests that increased teacher visibility in the cafeteria and teacher encouragement are not sufficient to improve overall student participation.

Figure 2 presents a revised conceptual model based on our findings, with additions highlighted with dashed lines. The revised model suggests that teacher encouragement and eating in the cafeteria with students does not rely on teachers' perceptions of taste or healthfulness, though these behaviors may further improve if perceptions also improve. Instead, the perceived value of the school-lunch program, such as the program's value in addressing student health or achievement, may mediate the relationships between teacher outreach and teacher encouragement and eating in the cafeteria. This model also posits that improvements to school-meal quality would be necessary to improve teacher perceptions of taste and healthfulness, and thus their participation in the school-meal program. This updated model should be tested in future studies.

With over 70% of teachers reporting exposure to the intervention at least monthly in the second year, the intervention dose delivered was fairly high for a school setting.[52] In an average intervention school, teachers received nine promotional newsletters, saw a short promotional video at a staff meeting, and had the opportunity to sample school meals at least nine times. As a half-time staff member was hired to implement teacher outreach activities, we do not anticipate that the dose delivered would be higher in other real-world settings.

This study has multiple limitations. The lack of teacher survey participation in 5 schools limited our ability to make inferences about all schools in the study. The lack of teacher-level demographic information prevented the incorporation of covariates that may act as unmeasured confounders. The multi-component nature of the intervention renders it difficult to identify which intervention components had the greatest impact on teacher behavior. We did not assess teacher values around school meals, which would have enabled us to test our revised conceptual model. Future studies should include measures of teacher-perceived school-meal value such as

student achievement or student health. Finally, the intervention might have had a greater impact if it was conducted with elementary school-aged students; teachers may be more influential role models for young children than for adolescents.[53] Future research should explore the utility of teacher role modeling in an elementary school setting.

This study provides insight into an under-studied, but important topic: teacher perceptions and behaviors surrounding school lunch. Few studies have explored teacher perceptions of school meals[46,50] and none are intervention studies. This study adds to the literature by proposing a conceptual model to be utilized and further tested in subsequent research. As this intervention was unable to improve teacher perceptions of healthfulness or taste, we were unable to establish a link between these perceptions, encouragement of school lunch to students, and role modeling. However, results indicate that teacher perceptions of school meals do not necessarily need to be improved in order for teachers to promote the program to students. Future studies should further explore determinants of teacher perceptions and values related to school meals as potential levers to improving participation in the school-lunch program.

Figure 2.1 Teacher Outreach Conceptual Framework

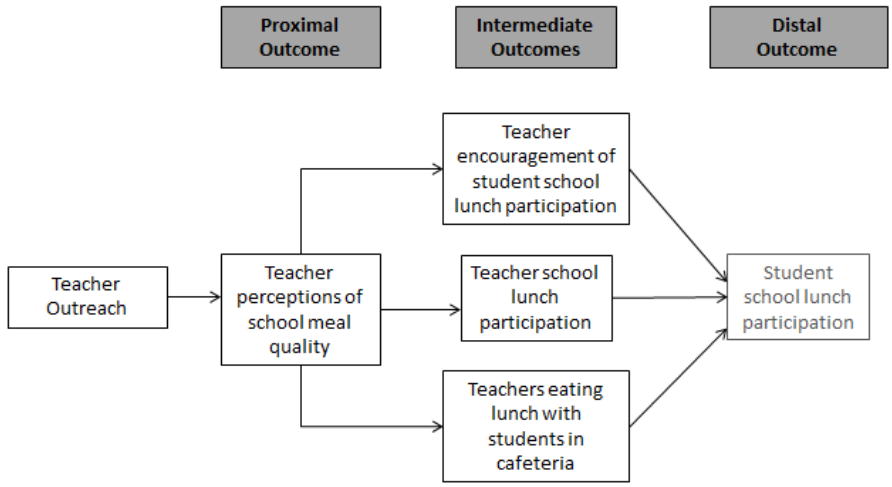


Table 2.1 Teacher Response Rates, Intervention and Comparison Schools

	Intervention Schools (n=9)	Comparison Schools (n=10)	P- value [a]
Number of teachers employed[b], median (IQR)	42 (37, 62)	45 (35, 56)	0.870
Baseline response rate, % ±SD	58% ±11%	53% ±9%	0.736
Follow-up response rate, % ± SD	50% ±9%	51% ±7%	0.921
Number of teacher survey responses (Total), median (IQR)	63 (35, 70)	52 (27, 65)	0.935

[a] P-value based on Wilcoxan Rank Sum Test for number of teachers and teacher survey responses. Response rate p-values based on t- tests.
[b] Number of teachers employed in follow-up year.
IQR: Interquartile Range

Table 2.2 Baseline Student Survey Characteristics, Intervention and Comparison Schools

	Intervention Schools	Comparison Schools	P- value [a]
School-Level Characteristics	**(n=12)**	**(n=11)**	
Students enrolled in grades 7-12, median (IQR)	890 (566, 1575)	932 (572, 1100)	0.758
Students eligible for FRPM, % ± SD	68% ±3%	58% ±5%	0.083
Student-Level Characteristics	**(n=3,625)**	**(n=3,215)**	
Student-Reported Race/Ethnicity, N (%)			<0.001
African American	144 (4%)	99 (3%)	
Asian	1,847 (51%)	1,418 (44%)	
Latino	749 (21%)	521 (16%)	
White	170 (5%)	433 (13%)	
Other [b]	715 (20%)	744 (23%)	
Student-Reported Gender, N(%)			<0.001
Female	1,544 (43%)	1,528 (48%)	
Male	1,770 (49%)	1,348 (42%)	
Other[c]	311 (9%)	339 (11%)	

IQR: Interquartile Range

[a] P-value for enrollment based on a Wilcoxan Rank Sum Test. P-value for FRPM eligibility based on a t-test. P-value for race/ethnicity and gender based on a Chi^2 test.

[b] Other comprised of other, multiple, or declined to state race/ethnicity.

[c] Other comprised of other and declined to state gender.

Table 3. Teacher-Reported Behaviors, Baseline to Follow-Up

Frequency (Times per Month)	**Intervention Schools (n=639)**[a]			**Comparison Schools (n=605)**			**Between-Group Difference in Change**[b] 95% CI
	Baseline Mean ± SE	**Follow Up** Mean ± SE	**Difference** Mean 95% CI	**Baseline** Mean ± SE	**Follow Up** Mean ± SE	**Difference** Mean 95% CI	
Eat with students in the cafeteria	0.33 ±0.09	0.35 ±0.14	0.02 -0.30, 0.35	0.49 ± 0.15	0.12 ±0.03	-0.37** -0.63, -0.11	1.46** 0.36, 2.55
Encourage students to eat school meals	2.39 ±0.35	2.24 ±0.38	-0.15 -0.97, 0.66	3.22 ±0.42	2.45 ±0.31	-0.76 -1.82, 0.29	0.21 -0.31, 0.72
Eat school lunch	1.33 ±0.11	0.96 ±0.18	-0.38** -0.64, -0.11	1.15 ±0.17	0.85 ±0.11	-0.31 -0.79, 0.18	-0.02 -0.59, 0.54

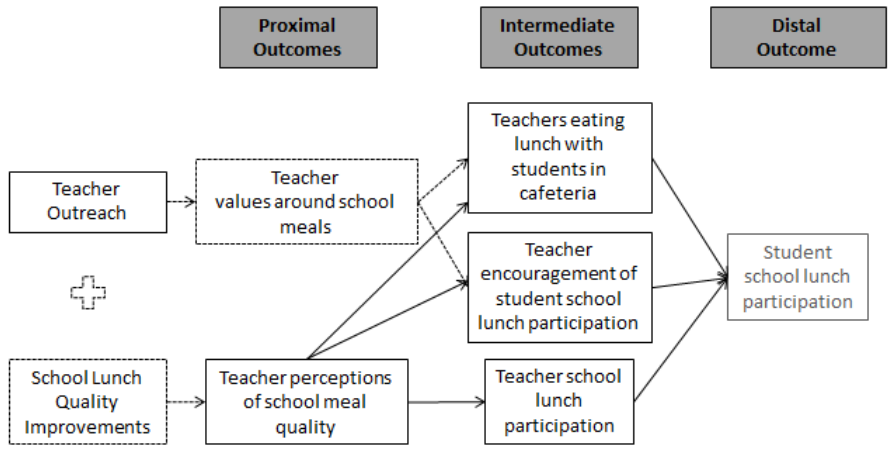
Values based on generalized linear models with a Gamma family log link and adjusting for school-level free and reduced price meal eligibility and clustering by school.

[a] N's vary slightly by question. Missingness range: <1-3%

[b] Change from baseline to follow up in mean frequency in intervention schools compared to comparison schools.

**p<0.01

Figure 2.2 Revised Teacher Outreach Conceptual Model



PAPER 3

Implementation leadership in school nutrition: a qualitative study

ABSTRACT

Background: While there is a need for innovative approaches to improving school lunch participation, implementing a new approach in a school setting can be challenging. Implementation science frameworks may offer insight into how leadership shapes implementation success, though it remains unknown if these frameworks, often developed in clinical settings, are relevant and translatable to a school nutrition context. This paper offers insight into how leaders might leverage their role to improve the implementation of school nutrition innovations, and contextualizes study findings in the existing implementation science literature.

Methods: Fourteen semi-structured interviews were conducted with school district leadership and staff involved in implementing a school lunch promotion intervention. Modified grounded theory was used to code and analyze interview transcripts.

Results: Four major themes emerged reflecting the ways in which leaders are perceived to influence implementation effectiveness: (1) leader understanding of the technical and operational details of the intervention; (2) leader ability to proactively develop and communicate intervention plans; (3) leader supervisory oversight over implementation staff and contractors; and (4) leaders acknowledgment that 'innovation' requires time and stakeholder input —the absence of which can threaten cohesion and buy in.

Conclusion: Implementation leadership functions in a school nutrition context appear similar, yet not identical, to those identified through other contexts, as already described in the implementation science literature. Specifically, this paper discusses how study findings intersect with the leadership domains comprising the Implementation Leadership Scale (ILS), as adapted for schools. Themes from this study are consistent with four of the five ILS constructs: Knowledgeable, Proactive, Perseverant, and Distributed Leadership. The fifth leadership construct, Supportive Leadership, was not a major finding in the data. Further, we identified an additional leadership domain, intervention framing, not included in the ILS. Future studies should explore how leaders can be perform their roles in ways that improve the implementation of nutrition interventions in school settings.

INTRODUCTION

School meals are often the healthiest lunch option for students.[3,23] Due to this, considerable effort has gone into developing and testing new strategies to promote school lunch participation and consumption of the fruits and vegetables offered in the program. Students, however, continue to participate at low rates[5] and eat poorly[25] despite these efforts. While there is a need for innovative strategies to improve student nutrition outcomes, embedding innovations in schools is difficult. In large, public sector contexts like schools, limited financial resources[54] and bureaucratic organizational structures[55,56] make it challenging to create and sustain change.

A heightened focus on *how* an intervention is implemented (i.e., put into place) may therefore help schools achieve better student nutritional outcomes. Public health interventions often fall short of their potential due a failure to attend to the contexts in which they are delivered or the processes through which they are implemented.[57] The interdisciplinary field of implementation science has emerged to guide systematic study into factors that shape implementation success. For example, implementation scientists may study how organizational contexts (e.g. structure, culture, and climate) influence the delivery of an intervention[58] and then tests strategies to improve organizational capacity for implementation.[59]

Swindle et al. highlight the potential utility of implementation science to overcome challenges documented in the public health nutrition literature.[60] This includes developing a common implementation terminology within the field of public health nutrition, enabling researchers to advance measurement and understanding of implementation and to test which implementation science theories and strategies are relevant and translatable to a public health nutrition context.

Frameworks from implementation science may help school nutrition researchers and practitioners understand and articulate how leaders can shape the implementation of innovative interventions. For example, school nutrition case reports suggest that leadership during implementation may lead to higher quality and consistency of implementation.[61–66] While these school nutrition studies provide valuable contextualized case examples, the potential to connect these cases to the constructs of existing implementation science theories or measures could provide greater opportunity to identify specific leadership functions or steps leaders could take to positively influence implementation. Currently, the field of school nutrition does not use a shared language around implementation leadership, rendering it difficult to build off of subsequent studies and advance our understanding of leadership. Implementation science frameworks on leadership may prove helpful for conceptual clarity. There is an established body of work from implementation scientists on how leadership style[67–71]and leadership behaviors[72,73] contribute to implementation effectiveness (i.e. how well the intervention is implemented as intended).[74] These frameworks break large, ambiguous concepts like leadership into specific functions with real-world application. However, it remains unclear if these frameworks, primarily developed in a clinical setting, translate to a school nutrition context.

This paper offers insight into how leaders might leverage their role to improve the implementation of school nutrition innovations. We worked with a school district, known for their interest in innovative strategies, to study the implementation process and outcomes of a multi-faceted school meal promotion intervention. The district contracted a local design firm to develop an innovative intervention. Upon creation of the project vision, the design firm concluded their portion of the project, and the school district implemented the innovative strategies alone. Against this backdrop, this paper has two purposes: (1) to characterize implementation leadership in the context of a school nutrition intervention; and (2) to contextualize study findings in the existing implementation science literature. Specifically, this study conducts in-depth interviews with school personnel regarding their implementation experiences and discusses findings within the context of implementation science frameworks.

METHODS

Study Design and Setting

The present qualitative study is part of a larger project examining the impact of a multi-pronged intervention to increase school-lunch participation and reduce plate waste by middle and high school students.[31] The intervention consisted of three components: (1) teacher outreach to enhance perceptions of school lunch; (2) cafeteria redesign to promote socialization and improve perceptions of the meal program; and (3) the sale of school lunch through newly added vending machines and mobile carts to improve convenience compared to the traditional cafeteria. A fourth component, an e-application to provide nutrition education and allow students to pre-order school lunch, was part of the initial intervention plan but was not implemented due to technical challenges. Details about the intervention components and implementation timeline are available elsewhere.[31] For the present study, we used in-depth interviews to explore the implementation context and process. Interviews were selected to elicit thoughtful reflections while also providing confidentiality to participants while discussing potentially sensitive topics. The study was approved by the Committee for Protection of Human Subjects at the University of California, Berkeley.

Twenty-four (12 intervention and 12 comparison) middle and high schools in an urban school district in California participated in the intervention over a three-year period. The intervention was conceptualized by the school district in partnership with a local design firm. The University of California, Berkeley and University of California Cooperative Extension overlaid the study design. After a high-level vision of the intervention was created by the partners, school district staff implemented the intervention components. The majority of district implementation staff worked in, or directly supported, the Student Nutrition Department. Qualitative interviews were conducted with district-level implementation staff responsible for the management, planning, and/or carrying out of the intervention in the 12 intervention schools.

Data Collection

Using purposive sampling, we interviewed a district staff member who worked closely with the research team, who then identified 13 additional district-level staff members involved in the management, planning, and/or implementation of the intervention. All recruited staff members participated in an interview. Interviews were conducted the summer following the end of the three-year intervention period. Interviews were conducted by the first author who had prior experience with qualitative interviewing. All interviews were held privately at the participant's place of work, with the exception of two interviews which were held at coffee shops. Participants gave informed consent before participating in interviews and were not compensated for their participation. The semi-structured interview protocol focused broadly on policies, structures, procedures, and culture of the organization as they related to implementation of the intervention. The interviews, lasting approximately 30-60 minutes each, were audio-recorded, transcribed verbatim, and uploaded to a qualitative data analysis software, QDA Miner Lite (version 2.06, Provalis), for data management and coding.

Sample Characteristics

Management staff ("leadership") who planned and oversaw implementation accounted for 50% of the interviewees. Leaders participating in this study consisted of mid-level Innovations Team members in the Student Nutrition Department (N=3), their supervisors (N=3), and a director of another district-level department (N=1). The other 50% of interviewees were "Implementation staff." Implementation staff participating in this study consisted of mid and lower-level staff in school meal operations (N=3), as well as information technology and administration (N=4). All implementation staff worked in or directly supported the Student Nutrition Department. Few interviewees were involved in the project or employed by the school district during the entire 3-year study period. One interviewee was only involved after the study period ended (i.e. during the sustainability phase). Of the 14 total interviewees, five were men and nine were women.

Analysis

Modified grounded theory was employed in the coding and analysis of the data. This approach is useful for examining concepts that are present in the literature while accommodating novel themes that emerge from the data. Analysis was focused on the intersection of implementation fidelity (i.e. the extent to which the intervention was delivered as intended) and leadership. Deductive codes were used for fidelity constructs, as these are established in the literature and provide a guide to assess implementation quality. Deductive codes were based on two aspects of fidelity: adherence to intervention protocol (i.e. how well the intervention was delivered as intended) and dosage (i.e. how much of the intervention was delivered).[75] Adherence codes reflect how well the final intervention components aligned with the initial project vision. Dosage codes reflect how often the intervention components were accessible to teachers and students over the 3-year intervention period. Codes related to the role and functions of implementation leaders were primarily inductive. As little is known about implementation leadership in school nutrition contexts, inductive coding was chosen to ground codes in the experience of participants. Leadership codes that co-occurred with, or were connected to, fidelity codes were the focus of the analysis. These codes identify leadership functions that are linked to the implementation quality.

The first author conducted line-by-line deductive and inductive coding of all transcripts, using both descriptive and evaluative codes.[76] In alignment with grounded theory, constant comparison was used;[77] the first author refined the coding schema throughout the process to allow for the consolidation of codes, the addition of sub-codes, and the inclusion of emergent codes. Further, the coding structure iterated with a review of relevant literature on implementation leadership. Once the coding structure stabilized and saturation was reached (ie. no new codes emerged and the codes had sufficient depth),[78] a codebook was created with a description and an example quote for each code. A second coder (KSM) used the codebook to independently code all 14 transcripts. The first author reviewed the coding of the second coder to determine whether codes were applied with reasonable consistency and no new codes emerged. The two coders then discussed codes and came to a consensus on salient themes.

RESULTS

Characteristics of Leadership in Implementation

Four major themes emerged reflecting how leaders are perceived to shape implementation success: (1) leader understanding of the technical and operational details of the intervention; (2) leader ability to proactively develop and communicate intervention plans; (3) leader supervisory oversight over implementation staff and contractors; and (4) leader acknowledgment that intervention framing can influence staff cohesion and buy in.

Divergent themes were not found across the leadership team and implementation staff, reflecting broad consensus for the implementation challenges encountered. In discussing their experiences implementing the school nutrition intervention, interviewees primarily highlighted challenges to implementing two of the four intervention components: meal sales through vending machines and mobile carts and the e-application. In the context of discussing leadership, participants presented numerous recommendations for the implementation of future interventions.

Technical and operations experience

Technical knowledge and operations experience was the primary factor affecting implementation effectiveness, as this theme intersected the most with fidelity in interviews. Two aspects of the intervention (the additional points of sale and the e-application) required significant technical knowledge in the areas of information technology (IT), construction, and maintenance. Key operations skill-sets included the understanding of regulations, such as health and fire codes, and contracting processes (i.e. hiring vendors for the vending machines, mobile carts, and the e-application). No staff member had previous experience implementing the intervention components, nor did they have access to technical assistance or training. They learned through "trial and error" (Participant 11, implementation staff) as they planned and implemented it. Reflecting upon this lack of knowledge, one participant said,

> *You cannot put…me working in NASA, because I don't have the experiences, you know...and, that was the whole thing... [there was] a lack of true experience, or the lack of direct experience [of the leadership team]. Just because you worked with one kitchen, it does not qualify you to do a skill this big, implementation.* (Participant 1, implementation staff)

Lack of technical and operations knowledge primarily influenced the ability to create accurate implementation plans. Staff mentioned that the leadership team had an interesting overarching vision, yet not a clear, detailed plan for how to realize it. *I think there is a real hole, a real void to fill between the ideas and what implementing at the district level actually looks like.* (Participant 4, leadership)

> *[The intervention] fell short in that [the leadership team] perhaps didn't have an operations background. For example, the original vision of the mobile cart [didn't] pass food safety guidelines, and I don't know [how that was missed]. But most people that have worked in food service operations would have seen that right away and had a red flag.* (Participant 4, leadership)

Others noted that even a good, high-level plan can be difficult to adapt without the requisite technical knowledge.

> *So, you can be the best business person in the world, set up the most beautiful contracts, arrange the top end of this flawlessly. But if it doesn't work, you wouldn't know where to go.* (Participant 2, leadership)

> *Like I remember sitting in a meeting with [the e-application vendor] and being like, "Cool, so how is that pre order going to work?" and [in talking internally] we're like, "… we have no idea." … we were trying to work in pre order, and all of a sudden we're like, we don't even know what that could look like, I mean, we have no clue…how that would ever even be possible.* (Participant 6, leadership)

Due to food safety regulations, the final mobile cart model had to include coolers and warmers and needed to be plugged in. This rendered the mobile carts heavy and cumbersome to move; the staff had to find locations where they could be used.

Similarly for the vending machines, leadership that lacked technical knowledge and operational experience inadvertently called for the wrong electrical set up, did not build maintenance into the vending machine contract, and initially selected machine locations that were in violation of the fire code. As a result, the vending machine roll-out was delayed and the majority of the machines were placed in inconvenient locations. Another participant noted that the leadership team did not anticipate all of the details that should be included in the vending machine implementation plan.

> *Visually, you can do this. I mean it's IT, it's electrical. But then, electrical is like going through facilities to do the contract which then means you have to go to the bidding process, which is another department. … as soon as you hit one button, then all of a sudden 15 others showed up and that process alone, just to purchase [vending machines] was like a six month process,. And that wasn't built in our timelines.* (Participant 5, leadership)

Interviewees talked about the importance of technical and operations expertise in solving problems that were encountered during implementation. Interviewees emphasized that the issues they had to navigate in implementing the school nutrition intervention were complex. For example, with the vending machine, issues with the power sources, software, and hardware arose. One participant said the complex nature of the vending machine issues,

was a big challenge and I think [the leadership team] spent a lot of time running in circles because there was a little bit of, you know, "I believe it's that component causing the problem," and the other one saying, "it's that component causing the problem." What we found was a mixed bag. The solutions came from different arrangements according to which machine and what schools we were talking about. So it wasn't one correction fit all. (Participant 2, leadership)

One staff noted that implementation was more successful when, about halfway into the implementation process, a participant with school meal operations experience was hired.

> *You had a dedicated kind of management person who was there to support this program… and do a lot of the research and do a lot of the supporting activity which [they] spent so many hours at, and working with the staff, and working with the technology, and making sure that we were doing the best that we could with what we had.* (Participant 7, implementation staff)

Staff noted that soliciting help from a director of another district department with construction and maintenance expertise led to the resolution of many of the vending machine issues. This director located and resolved a problem with the electrical circuits and worked with the appropriate vendors and district staff to identify and resolve connectivity problems.

Despite multiple project setbacks with many of the intervention components, the team continued to try different strategies to resolve the issues they experienced and were ultimately able to roll out all components aside from the e-application.

Interviewees offered suggestions for increasing the technical and operations knowledge of the leadership team. First, if those in leadership roles do not have the necessary expertise, then they need to bring in those with the expertise in the early planning phase, and continue to draw on their support throughout implementation. As one participant said, *So I would say first of all the [leader] needs to have a lot of resources, knowing who to reach out to and, and be able to [be] self-sufficient in finding the resources.* (Participant 1, implementation staff)

One participant highlighted the consequences of not knowing how to access the appropriate expertise, saying, *So somebody needs to be the responsible person and then know where to go if something isn't correct. If those resources aren't there, you will struggle.* (Participant 2, leadership)

Second, participants stressed the importance of involving these experts both early and often. Staff mentioned that those with essential operations and technical knowledge were either not involved or not given a voice in early planning. One participant emphasized this, saying,

> *I would make sure that they have everyone at the table in the planning process. Their Buildings and Grounds equivalents, if they have an IT team, have them at the table. Just so everybody fully understands everything that goes into it…and [is involved] in the planning process.* (Participant 4, leadership)

Planning

Dimensions of planning not connected with technical and operations experience also emerged as important. Participants highlighted that how leaders created and communicated plans affected implementation effectiveness. Participants emphasized how leaders must clearly communicate implementation plans to staff, especially with a complex project. One participant, in talking about the e-application development, said,

> *Student nutrition… had kind of a grand plan for how everything should work. But also at the same time, I don't think they really knew what they wanted or what they want to get out of the app.* (Participant 3, implementation staff)

One participant discussed how lack of a clear plan and roles causes staff confusion about next steps for implementation.

> *I would say a lot of it was just lack of communications…and lack of clarity. And so causing me, or my supervisors, or the entire staff team [to ask] "Where are we going, what are we doing? Why are we changing a few times a week?" Nobody has any idea what needs to be done.* (Participant 1, implementation staff)

A participant highlighted the importance of communication in role assignment, stating,

> *So again it goes back to how do you create the team, and the messaging, and the communications to the team. So it's clear what the roles are, and why each person has the role they have.* (Participant 8, leadership)

Further, lack of time to adequately plan for implementation contributed to implementation effectiveness. Some participants emphasized that one of the reasons why the selected mobile cart model was less functional than envisioned is because the leadership team purchased carts quickly- without gathering detail about how the carts would work in the schools. Interviewees discussed that the leadership team made "rushed decisions" (Participant 1, implementation staff) early on in the implementation process. The leadership team members talked about how tight grant timelines forced them to make implementation decisions quickly and move forward with existing implementation plans, even when these plans did not appear to maximize intervention fidelity. As one participant noted, *We had timelines… and I don't think we gave ourselves the freedom and flexibility that we needed.* (Participant 6, leadership)

Supervisory Oversight

Leadership team members mentioned that those in implementation leadership roles need to have the ability to mandate staff participation and negotiate with other departments and external contractors. The Innovations Team members were leading the project and were charged with overseeing the day-to-day implementation. Those who supervised the Innovations Team and the Innovations Team members were supportive of the project. However, the Innovations Team did not explicitly supervise the implementation staff and had no control over their working priorities. Instead, the majority of the leadership team and the implementation staff were in similar positions within the overall hierarchy.

Leadership talked about how mandating staff participation cannot come from either the bottom or the very top of the organizational hierarchy. One leadership team member mentioned that they were responsible for encouraging the Operations Team to participate but did not have the power or status to successfully convince staff. This particular participant was not hierarchically positioned above the staff performing implementation activities.

> *I think there has to be strong leadership leading the way and getting the team reunited because it is an operational shift... There has to be someone who can mandate that as part of people's job responsibilities and I didn't have that ability.* (Participant 5, leadership)

Contributing to hierarchical challenges, the top leaders also may not be able to effectively mandate participation because, as one participant said, they aren't "*necessarily part of the team*," (Participant 5, implementation staff). One participant noted that a high-level administrator who oversaw multiple departments (including Student Nutrition), *could mandate things but…wasn't there to see it day to day. You need someone who's going to [oversee] day-to-day operations.* (Participant 5, leadership)

Further, leadership team members noted that the Director of the Student Nutrition Department did not have a leadership role in the project, with position turnover and vacancy contributing to lack of participation. The Director position was vacant for approximately half of the intervention. As one interviewee said,

> *We were without a director for a really long time… But in that time, we're trying to launch all these things…but then we didn't have someone who can mandate [the intervention] has to happen.* (Participant 5, leadership)

Another participant emphasized that a Department Director role has the power to influence other departments saying, *In the absence of leadership, there's no one to do the negotiations.* (Participant 4, leadership)

The leadership team was able to access the power they needed to resolve vending machine problems by connecting with the director of another department. This person was successful in convincing the maintenance contractors to re-do their electrical work at no additional cost because the contractors had previously worked with this person and knew that future contracting decisions would also be made by this person.

Intervention Framing

Interviewees discussed that framing the intervention as innovative had implications for implementation success. This framing influenced how leaders made decisions. As one participant said, *[The intervention] was looked at as something new as opposed to how we could coordinate and streamline it with the...programs that we already had going on.* (Participant 8, leadership)

Framing the intervention as innovative and new seems to have prompted leaders to develop new processes instead of building off of existing equipment and processes. For example, the new mobile cart created specifically for the intervention was less mobile and more complicated than the existing, approved "grab and go" breakfast carts, which might have been adapted for use. A participant observed that implementation may have worked better if the intervention had built upon the existing breakfast carts, stating:

> *A lot of thought was already put into breakfast grab and go lines. So how do we repurpose those lines to also be used at lunchtime because it's the same concept… It's just now lunch versus breakfast. I think that's one of the biggest things [that would have improved implementation success]. Instead of creating something new, extending [existing processes].* (Participant 8, leadership)

Further, since the project was managed as an innovation, the new and distinct Innovations Team was created to lead implementation without including the existing Operations Team as leadership

on the project. Operations team members helped with implementation but were not intimately involved in leading or planning for implementation. One participant said, *I don't know that there was a lot of connection with the planning process between the Operations Team.* (Participant 8, leadership)

Implementation staff and leadership alike noted that having both the Innovations Team and the Operations Team working together on the project from the beginning would have improved implementation effectiveness. The focus on innovation, however, created a dynamic in which the two teams had difficulty collaborating. As one participant said, *I think a lot of the [Operations Team] sees…the work that [the Innovations Team does] as very separate, when the work that we need to do needs to be much more tied.* (Participant 6, leadership)

Some leaders highlighted that reframing the project as something that extended existing programs or utilized staff with knowledge of those programs, would have helped improve collaboration between the two teams. Implementation staff noted that another way to improve collaboration between teams would be to invite all staff to give feedback on implementation plan development. This would help staff feel like their perspective was valued and could increase staff buy-in and collaboration around implementation. Further, it appeared that there was a discrepancy in how the intervention was framed at the top of the leadership chain as compared to how it was viewed by the Operations Team. While the intervention may have been thought of as "innovative" and a step towards a permanent redesign of the school meal landscape at the top of the leadership chain, it was messaged as "temporary" to these implementation staff. For example, one participant said,

> *I think the hardest part was that [the intervention] was seen as a separate, temporary project - it was a pilot. But, that doesn't mean that pilots just end, right? It's the point of a pilot is to see how it could live on. But that wasn't [communicated] as successful[ly].* (Participant 9, implementation staff)

Another stated, *I don't think it's been really well explained…this idea of innovation…for some reason it seems like that message isn't [getting through to staff].* (Participant 5, leadership)

Finally, it was unclear to implementation staff why this particular intervention was selected. One participant said, *I think it was a loss in translation of why we're doing this*. (Participant 6, leadership) Another said, *We hadn't built a case as to why this was necessary for our [students]*. (Participant 5, leadership) This lack of clarity, coupled with the "temporary" messaging, may have influenced staff ownership of the project.

DISCUSSION

This study provides a rich description of how leaders can influence implementation of a school-based nutrition intervention and provides key takeaways for researchers interested in implementation leadership and schools attempting to innovate, particularly in the realm of school nutrition. Results indicate that a leader's access to technical and operations expertise influences their ability to develop useful implementation plans. Further, a leader's ability to proactively develop and clearly communicate plans to staff impact implementation effectiveness. Results

also point to the importance of leaders' supervisory oversight in successful implementations; leadership functions are perceived to be more successfully performed when leaders have appropriate authority in the organization. Finally, leaders framing the intervention as 'innovative' appears to have had some negative implications for staff collaboration and implementation success.

Dimensions of leadership that emerged as important in our study of this school nutrition intervention largely match dimensions of leadership that have been identified through studies of other implementation contexts, as already described in the implementation science literature. To our knowledge, only four prior studies (Locke et al.,[73] Lyon et al.,[79] Lee et al.,[80] Shapiro et al.[81]) have used the Implementation Leadership Scale (ILS) to consider implementation leadership in an educational setting. Our results, however, are the first to illustrate how these manifest in the context of school nutrition settings. Findings from this study align well with the constructs measured by the ILS. The ILS was developed by Aarons et al.[72] to measure strategic leadership for implementation in a mental health setting. The original scale includes four leadership constructs: (1) Knowledgeable Leadership; (2) Proactive Leadership; (3) Perseverant Leadership; and (4) Supportive Leadership. Shapiro et al.[81] noted that the ILS had lower scale reliabilities in the school context rather than a clinical setting, likely because the supervisor was not a single person, but distributed among a team of people. Locke et al. explored the ILS in a school context, identifying the additional dimension of Distributed Leadership.[73] Themes emergent from this study align with four of the five previously identified ILS constructs: Knowledgeable, Proactive, Perseverant, and Distributed Leadership.

A leader's access to technical and operations knowledge, the predominant theme identified as influencing implementation success in this study, aligns with Knowledgeable Leadership from the ILS. Knowledgeable Leadership is characterized as being knowledgeable and able to answer questions about the intervention and implementation.[72] Both the present study and ILS highlight that knowledge about the intervention and the implementation process is key to effective implementation. This present study adds specificity to the areas of knowledge needed for implementing technology-based innovations in a school nutrition context; leaders need an understanding of how the intervention relates to school operations and technology. Data from this study offer a unique perspective on Knowledgeable Leadership, suggesting that leaders do not necessarily have to have the knowledge themselves. Instead, they can build a network of experts to fill in the knowledge gaps. An additional marker of Knowledgeable Leadership may be knowing where to find knowledge and get assistance when needed.

The need, demonstrated in the present study, for leaders to taking a proactive approach to implementation planning, fits with the ILS concept of Proactive Leadership. Proactive Leadership is characterized as establishing clear standards for implementation, developing a plan to facilitate implementation, and removing obstacles to implementation.[72] Lee et al. demonstrated a direct relationship between perceptions of Proactive Leadership and the dosage delivered of a school-based social and emotional learning intervention.[80] Findings from the present study, in a school nutrition context, posit that an additional component of Proactive Leadership includes clear communication of plans to staff. Studies cataloguing lessons learned from school nutrition intervention studies have identified communication between implementers as key to implementation success.[63,65,66] Further, leaders did not always have ample time to

gather the information needed to make strategic implementation decisions. This suggests that more lead-time to be proactive may allow for higher-quality implementation. Results from the present study also highlight the possible connection between Knowledgeable Leadership and Proactive Leadership in school nutrition; a lack of technical and operations knowledge can lead to the development of an unclear, and sometimes inaccurate, implementation plan, whereas the inclusion of technical and operations experts may lead to the removal of implementation barriers. The relationship between the two constructs should be explored in future studies.

Leaders demonstrated perseverance in implementation, continuing to adapt and move forward despite implementation challenges. This fits with Perseverant Leadership dimension of the ILS: persevering, carrying on, and reacting to critical issues throughout implementation.[72] Perseverant Leadership may be particularly important in the education sector where implementation is a difficult process and can take many years to complete due to many factors including system complexity and lack of capacity.[82] Leaders' determination despite obstacles led to the implementation of most intervention components.

Results highlight the need for more nuance in ILS' Distributed Leadership, the leadership of many individuals across teams and hierarchical levels,[73] in a school nutrition context. We posit that different implementation leadership behaviors are best performed by distinct positions within an organization. For example, leveraging influence and relationships to accomplish goals is most effective when performed by staff with appropriate authority over others. Encouraging staff participation is most effective when coming from staff with appropriate authority and who oversee day-to-day operations. This is corroborated by Birken's theory of middle management which posits that middle managers (i.e. those positioned between high-level leaders and on-the-ground staff) are hierarchically poised to most effectively "sell" the value of the intervention to staff.[83]

Supportive Leadership (supporting employee efforts to learn about and use an intervention and recognizing employees for these efforts[72]) was not a predominant theme in the present study. This is surprising, as this domain was the predominant theme in Locke's exploration of the ILS in a school mental health context.[73] The absence of this theme does not necessarily reveal its absence in the project. It may be that support was adequate, but not noteworthy relative to other reflections they shared on implementation. For example, some interviewees mentioned that leaders were supportive of the intervention though did not describe support in detail or connect support to implementation effectiveness. Furthermore, Shapiro et al.[81] found reduced perceptions in Supportive Leadership throughout implementation of a school-based mental health intervention, unique among the ILS constructs. Therefore, Supportive Leadership may not have emerged as a theme by nature of when our data was collected relative to intervention initiation. For this and other reasons, the absence of this theme in the data does not enable us to draw conclusions about the perceived relationship between supportive leadership and implementation fidelity. To resolve this ambiguity relative to Locke's findings, this may be a topic to probe directly in future studies of school nutrition interventions.

We identified one leadership domain that is not included in the ILS: intervention framing. Results indicate that intervention framing by leaders influenced staff participation and leaderships' implementation strategy. Participants highlighted that staff may have been more motivated to implement the intervention if leadership had not messaged the intervention as a

temporary requirement, and implementation may have proceeded differently if a service expansion rather than innovation was being discussed. Further, they noted a gap in explaining to staff why the intervention was important to implement. Other studies demonstrate that value compatibility with implementation staff is a contributor to implementation effectiveness,[58] and this study highlights the influence that leaders may have in addressing staff perceptions through intervention framing. Further, this study illustrates that leadership's own conceptualization of the intervention can impact their implementation leadership behavior.

Importantly, the ILS was not only designed for clinical settings, but it was also designed to put an evidence-based practice in place. Although the ILS constructs mapped quite well, this district was trying to implement something they were innovating. This may explain differences in the leadership themes that emerged. For example, it may be different to be supportive of a previously tested intervention rather than an innovation. Further, intervention framing may be harder to do without previous evidence to demonstrate how the intervention might impact the intended recipients. Finally, there has been some discussion in the implementation science literature regarding leadership dimensions (e.g., "Available Leadership") of importance for *sustaining* implementation,[84] which are not considered within this study which asks participants to reflect upon the implementation of a new initiative.

Beyond the alignment with implementation science frameworks, findings from this study offer practical considerations for school nutrition leaders. First, ensuring that implementation leaders have access to technical and operations experts is key when implementing technology-based innovations, strategies that require significant acquisitions or interventions that modify the environment. Leaders need to be aware of what skill-sets are needed to successfully implement the intervention and bring experts with these skill-sets to the table early on in the planning process. One strategy to address this is building technical assistance into the intervention. Evidence suggests that school-based health interventions are implemented with greater success if technical assistance is available to schools.[85,86] However, findings from the present study demonstrate that leaders need to know what kinds of technical assistance they might need and how to access this assistance in order to proactively include in their plans. For example, leaders in this study had expertise in innovation and public health nutrition but did not anticipate the operations and technical expertise needed. Another potential strategy is to incorporate a technical review process into the planning stage to allow those with expertise to provide feedback on the feasibility of the implementation approach. To the authors' knowledge, this strategy has not been tested in school settings. However, schools often have limited financial resources and this would need to be accounted for in their intervention budgets.

Second, leaders may consider including staff tasked with carrying out the implementation plan in the early planning process. Organizations often overlook including the implementers in planning, but their involvement improves project ownership.[87] Including staff with extensive school nutrition backgrounds could also lend a critical perspective on what types of implementation strategies work within the school context. Further, attention should be paid to how leaders message the intervention purpose to their staff. Value alignment is a key contributor to implementation effectiveness in the implementation science literature.[88] Without clear and convincing communication about the intervention purpose, it is difficult to mobilize staff. [30,31]

Finally, leaders should consider the potential negative externalities of innovation messaging.

Framing the intervention as innovative had implications for planning, resource allocation, and for staff collaboration. Within large bureaucracies, where changing existing systems is difficult,[56] it may be necessary to garner support from the existing systems and staff that could aid in implementation of a new intervention. An innovation lens may inhibit this support. Further, a focus on the final outcome of an innovation without thorough attention to the steps needed to achieve the goals may contribute to low-fidelity implementation.

There are limitations to this study. Interviews were primarily based on perceptions of the leadership functions that could have improved implementation and not solely on the functions that did promote successful implementation. Interviewees may have focused more on the barriers as more questions were asked about barriers than facilitators. Further, the study was a retrospective exploration of leadership functions. Due to these two factors, it is difficult to make assertions about which leadership functions are most important for implementation effectiveness. The study was also conducted in one school district only; results are not necessarily generalizable to other interventions or districts outside of this context. However, the focus on one district allowed for an in-depth exploration of this particular context. Further consideration of adapting the ILS to a school nutrition context will require the inclusion of multiple school districts.

This study connects school nutrition research with implementation science concepts: building a shared language around implementation in this context and providing key takeaways for schools attempting to innovate. Findings support that implementation leadership constructs are similar in a school nutrition context to other implementation contexts and offer additional dimensions to the current conceptualizations of implementation leadership. Future studies should explore how leaders can perform their roles in ways that improve the implementation of nutrition interventions in school settings.

CONCLUSION

This dissertation contributes to the literature on the efficacy and implementation of school-meal promotion strategies.

Paper 1 sought to explore the theoretical pathways through which the intervention was expected to increase participation and decrease plate waste: student perceptions of meal quality and convenience. Relative to students in control schools, students in intervention schools saw marginal improvements in perceptions of fullness and taste for 8th grade students only while perceptions of lunch lines remained unchanged. As only marginal improvements were seen and findings were inconsistent across grades, these findings help explain why our distal outcomes, school lunch participation, plate waste, and fruit and vegetable consumption, did not markedly improve. Further, poor perceptions of school meal quality from both intervention and control schools indicate that changes in the quality of school meals may be required in order to improve school lunch participation and intake.

Paper 2 introduced a conceptual model for the teacher outreach component of the multi-pronged intervention. Relative to control schools, teachers in intervention schools reported increases in eating with students in the cafeteria. Further, students at intervention schools had a relative increase in agreement that adults at their schools encouraged them to eat school lunch. No changes were seen in teachers' perceptions of or participation in school meals. Based on these findings, a revised conceptual model was proposed. The revised model suggests that the perceived value of the school-lunch program, such as the program's value in addressing student health or achievement, may mediate the relationships between teacher outreach and teacher encouragement and eating in the cafeteria. As teacher perceptions remained unchanged, the model also posits that improvements to school-lunch quality are necessary to improve teacher perceptions of meal quality, and thus school-lunch participation.

Paper 3 utilized semi-structured interviews to characterize implementation leadership during the intervention. Results indicate that a leader's access to context-specific technical and operations expertise influences their ability to develop accurate implementation strategies. A leader's ability to adapt plans in face of changing contexts and clearly communicate those plans to staff impact implementation effectiveness. Results also point to the importance of leaders' supervisorial oversight in successfully leading implementation; leadership functions such as influencing others to assist with implementation are more successful coming from leaders with more power in the organization. Finally, leaders messaging the intervention as 'innovative' had negative implications for implementation strategies and staff collaboration. Results largely align with four of the five Implementation Leadership Scale (ILS) dimensions: Knowledgeable, Proactive, Perseverant, and Distributed. Results suggest that future work to adapt the ILS to a school nutrition context explore the role of leader's framing of the intervention in implementation effectiveness.

This dissertation raises many important questions about improving school lunch programs. Papers 1 and 2 highlight the potential role of school lunch quality in both student and teacher school lunch participation. Questions for future research on meal quality include: (1) What types of meals are perceived as high-quality by students and teachers? (2) How do definitions of quality vary by student or teacher socio-demographics? (3) Do improvements to school-lunch

quality increase school lunch participation rates and reduce food waste? (4) Given the financial constraints of school meal programs, what are effective, low-cost strategies for improving school-lunch quality? All 3 papers illustrate the challenges of implementing new interventions in a school setting. Future research questions for implementation in school nutrition include: (1) What types of technical assistance improve implementation effectiveness? (2) Does implementation leadership training improve implementation effectiveness?

The National School Lunch Program has great potential to improve child nutrition as nearly all children in the United States have access to the program. However, issues with program uptake and food waste remain. Investments in creative interventions and implementation science are needed to move the dial on student nutrition. This dissertation is a meaningful step towards identifying intervention strategies and implementation considerations for school-lunch promotion.

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