

OPPORTUNITIES AND CHALLENGES OF IMPLEMENTING COMBINATION STEAM AND CONVECTION OVENS IN MISSISSIPPI SCHOOL KITCHENS

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ABSTRACT

PURPOSE/OBJECTIVES

The Mississippi Office of Child Nutrition provided a competitive grant program named Statewide Nutrition Integrity Assessment (NIA) that helped schools obtain combination steam and convection ovens (i.e. combi ovens) as a replacement for traditional deep fryers. While equipment and infrastructure are important determinants of child nutrition, literature is sparse on the topic. This study evaluates the current status of the adoption of combi ovens in schools across the state and identifies barriers to implementing the change.

METHODS

A two-tiered survey consisting of a structured questionnaire and a phone interview was used for data collection. Questionnaires were distributed electronically to all Child Nutrition Directors (CNDs) in the state, who were asked to provide information separately for each school within their respective districts. The CNDs were phoned for follow-up interviews for additional comments on challenges and plans. This study included data for 306 schools across the state that had onsite production kitchens and had surveys completed (34.6% response rate).

RESULTS

About three-fourths of schools in the sample had at least one functioning combi oven. Approximately 78% of schools had completely removed fryers from their kitchens. Respondents reported various funding sources utilized to obtain combi ovens, including federal grants, district funds, and internal discretionary funds, in addition to the NIA grant, which was the initial impetus. Barriers to purchasing and maintaining combi ovens included the cost of maintenance, infrastructure limitations such as plumbing and space deficiencies, and lack of staff training.

APPLICATION TO CHILD NUTRITION PROFESSIONALS

Findings that most child nutrition programs willingly made changes in their facilities after encouraged by a state-coordinated initiative suggest their commitment to feeding healthy foods to children. Financial, physical, and other obstacles that make it difficult to implement and maintain the change present opportunities for future areas of improvement. Findings from this study may apply to other child nutrition programs in the United States.

KEYWORDS: Combi Oven, School Nutrition, Equipment, Infrastructure, Funding

INTRODUCTION

The National School Lunch Program (NSLP) provides free and reduced-price lunch to nearly 30 million children each day, and the School Breakfast Program (SBP) provides free and reduced-price breakfast to nearly 15 million children in the United States daily (U.S. Department of Agriculture, Food and Nutrition Services, 2021). To ensure that meals offered through the NSLP and SBP are well-balanced and nutritious, the USDA has established nutrition standards that these meals must abide by in order to be reimbursed (U.S. Department of Agriculture, Food and Nutrition Service, 2019; U.S. Department of Agriculture, Food and Nutrition Service, 2017). In 2011, these standards were updated to ensure that school meals were consistent with the latest Dietary Guidelines for Americans. The revised standards require schools to limit calories, decrease sodium, and limit saturated fat, while increasing fruits and vegetables, whole grains, and low-fat and fat-free dairy products offered on daily menus (U.S. Department of Agriculture, Food and Nutrition Services, 2011).

Although the status of equipment and infrastructure in school kitchens might affect the ability of Child Nutrition Programs to meet the required nutrition standards and provide healthier meals, there has been limited discussion on this topic in the literature (O'Neill et al., 2020). School kitchens and updated equipment may influence parent, staff, and child perception of school meal programs, and improving kitchens and infrastructure could lead to increased consumption of school meals (O'Neill et al., 2020). The majority of schools participating in NSLP and SBP reported lacking some kitchen equipment to meet nutrition guidelines, and about half of the schools stated a need for infrastructure changes (The Pew Charitable Trusts, 2013). An improved understanding of the extent and the reasons for equipment and infrastructure deficits in school kitchens could help local schools provide healthier meals for American children.

Mississippi may be particularly vulnerable in terms of lacking child nutrition equipment and infrastructure. In a 2014 study, 95% of Mississippi schools reported lacking at least one type of equipment that would help prepare and/or serve healthier school meals; and more than 70% of schools in Mississippi stated needing kitchen infrastructure changes. Both of these percentages are substantially higher than national averages (The Pew Charitable Trusts, 2014). Furthermore, Mississippi was ranked the second highest of all states in childhood obesity rates according to the data from the National Survey of Children's Health (Robert Wood Johnson Foundation, 2018; U.S. Census Bureau, 2018).

To address these issues, the Mississippi Department of Education launched the Statewide Nutrition Integrity Assessment (NIA) program in mid-2000s. (Center for Mississippi Health Policy [CMHP], 2013). Administered by the Mississippi Office of Child Nutrition and funded by a private foundation, the NIA program offered a competitive grant assisting schools to obtain combination steam and convection ovens (combi ovens) as a replacement for traditional deep fryers. As compared to fryers, combi ovens use convection, steam, and a combination of steam and convection to cook foods; therefore, potentially reducing calories from fat and saturated fat in meals served to children (WebstaurantStore, n.d.). In addition, several brands of combi ovens promote their advanced features that may facilitate safer, efficient, and more personalized food production methods (Rational, n.d.; Sager, 2019), thus potentially creating a more effective work environment for local school nutrition program operators (CMHP, 2013). The National Food Service Management Institute (now Institute of Child Nutrition) described combi ovens as “a

standard piece of equipment for schools” that provide higher productivity, blended cooking options, and ease of cleaning (National Food Service Management Institute [NFSMI], n.d, p. 25).

The NIA program first introduced combi ovens to three Mississippi schools in 2006 with the condition that they would remove existing fryers (CMHP, 2013). To date, the program has provided a total of 379 combi ovens to qualifying schools across the state receiving grant funds (Carithers et al., 2020). As of 2013, 451 schools in Mississippi (56%) had obtained a combi oven from any funds, and 64.7% of all Mississippi schools with onsite production kitchens reported no longer serving fried foods in meals served to children (Chang et al., 2016). The growing implementation of combi ovens calls for a better understanding of how the changes were possible, and what may have been obstacles to those that could not implement the change.

The purpose of this study was to assess the implementation of combi ovens and the removal of traditional fryers since the inception of the NIA program and identify difficulties and successes of implementing combi ovens. Using a survey of the population of Child Nutrition Directors (CNDs) in Mississippi, this study addressed the following questions: 1) How many schools currently have functioning combi ovens, and how were they acquired? 2) How many schools still have fryers and why have they not been removed? 3) Were infrastructure needs a challenge associated with implementing a combi oven? The findings can contribute to building a knowledge base about the status of equipment and infrastructure of school production kitchens, and provide practical implications for child nutrition policymakers and practitioners in other places instigating similar changes.

METHODS

A two-tiered survey consisting of a structured questionnaire and a phone interview was used. The phone interview was intended as a follow-up to verify the questionnaire responses electronically received and encourage additional qualitative inputs that may have been omitted in written responses. The survey procedure was determined exempt from approval under 45 CFR 46.101(b) by the University of Mississippi Institutional Review Board in September 2019.

Survey Instrument

The survey instrument was developed based on the Phase I and Phase II NIA outcome surveys, conducted in 2012-2013 and 2015-2016, respectively. The questionnaire was created as a Microsoft Excel spreadsheet instead of standard survey software to allow for customization. Questionnaires were customized for each public-school district with names of all schools within the district displayed as column headings, to prevent omission of any school. Respondents were asked to provide information regarding the number of functional combi ovens, funding sources for each combi oven, the status of fryers, any reasons for non-removal of fryers, needs for kitchen equipment and infrastructures, and additional comments. Categorical choices were made in cell drop-down menus in the spreadsheet, and open-ended comments were directly entered by the respondents.

Two questionnaire items assessed the status of the removal of fryers and the reasons for removal: *“If the school uses a fryer, would you remove fryers if the school had combi ovens?”* and *“If the school did not or would not remove fryers, what would be the reason?”* For the first question,

respondents were provided with four answer choices: “1. N/A. The school no longer uses fryers,” “2. Combi ovens were obtained, but fryers were not removed,” “3. Fryer would be removed if combi ovens were obtained,” and “4. Fryer would not be removed even if combi ovens were obtained.” If respondents chose 1 or 3, the second question was skipped. Those who answered 2 or 4 in the first question were given four choices in the second question: “Fryers would still be needed as a backup,” “Fryers would still be needed for purposes other than school meals, such as catering or events,” “Fryers would not be removed due to the lack of administrative support,” and “Fryers would not be removed for other reasons.”

Infrastructure needs were assessed by the following question: “*How critically are the following infrastructure changes needed at each school to meet the new meal requirement?*” For this question, respondents were presented with six infrastructure components – physical space, electrical capacity, natural gas capacity, plumbing capacity, ventilation, and remodeling – and asked to rate each component as “not in need,” “somewhat in need,” or “in critical need.”

Survey Sample

Questionnaires were sent to all 146 district CNDs, who oversaw a total of 885 schools in the state of Mississippi. Although the study initially planned to include responses from all districts in the state, findings for this paper were based on responses received by March 2020 when the data collection stopped. Of 72 CNDs who responded, 67 also completed the follow-up telephone interviews providing information for 316 schools across the state (35.7% response rate). Of those, ten schools did not have a fully operational onsite kitchen but instead served meals prepared and delivered from another school. Excluding these satellite schools, the final sample for analysis consisted of 306 schools with a final response rate of 34.6%.

Survey Distribution

Before the survey distribution, the study objectives and the survey schedule were presented at the State Child Nutrition Conference in July 2019. In November 2019, questionnaires were distributed electronically as email attachments to all CNDs in the state. Non-respondents received reminders in December 2019 and February 2020. In March 2020, the survey was indefinitely suspended due to COVID-19. The completed questionnaire files returned via email to the principal investigators were stored in the University’s secure cloud server. For the CNDs who returned the questionnaires, follow-up telephone interviews were scheduled within a week of survey receipt.

Three trained graduate assistants conducted telephone interviews to verify information gathered electronically, rectify any quantitative misreporting due to misinterpretation of questions, and encourage additional qualitative inputs to elaborate or expand upon responses. It should be noted that there were a few instances (n=12) where funding sources (e.g., the NIA grant or federal funds) were misclassified as other sources. The phone interview was particularly helpful to elicit elaboration on the open-ended question “*Any additional information you would like to mention related to equipment and infrastructure issues at this school?*” Phone interviews were able to obtain new or additional comments for 82 instances that were left unanswered or answered vaguely. Upon completion of phone interviews, graduate assistants entered the responses received on the questionnaire as well as the interviews into the secure Qualtrics server. To ensure objectivity, telephone interview and data entry for each district were never performed by the same graduate assistant. Because the district CNDs provided a separate set of answers for each school, data were formatted with each school as the unit of observation.

Additional Data

Information about schools was obtained from the National Center for Education Statistics (NCES) and matched to the survey data using the school and district identifiers. Examples of additional data included: grade levels the school served, Title I status, enrollment sizes, and the percentages of students eligible for free or reduced-price NSLP meals.

Data Analysis

Stata 16.0 (StataCorp, 2019) was used for data analysis. Chi-square goodness-of-fit test, one-sample t-test, and two independent sample t-test were used. A significance level of $\alpha = .05$ was used. Frequencies and percentages were reported for quantitative responses about the status of combi oven implementation and infrastructure needs. Two-sample t-tests were used to compare infrastructure needs by combi oven status.

Qualitative responses provided further explanations of descriptive statistics. The research team identified patterns among the qualitative responses, which were first coded and counted. Some comments were quoted verbatim. One of the researchers, not involved in the data entry stage, reviewed the qualitative analysis to verify objectivity of interpretations.

RESULTS AND DISCUSSION

Table 1 shows the characteristics of the schools in the sample. To verify the representativeness of the sample, the characteristics for all schools in the state are also presented. The schools in the sample represented all K-12 grade levels. Goodness-of-fit tests showed that the sample had a balanced representation of kindergarten (45.1% in the sample compared to 40.9% statewide), elementary (58.8% in the sample compared to 56.6% statewide) and middle schools (46.7% in the sample compared to 45.7% statewide) in Mississippi but had a somewhat low representation of high schools (30.4% compared to 38.6% statewide, $p < .01$). Note that the grade levels are not mutually exclusive because many schools served grade levels crossing over the traditional elementary, middle, and high school classifications. The percentage of Title I schools in the sample (86.9%) was significantly greater than that for the entire state (70.3%), which suggests that the sample over represents schools serving low-income populations. The average enrollment size for schools in the sample (518.4 students) was greater than the state's overall average (450.8 students). The sample was comparable to all schools in the state in terms of the percentage of students qualifying for free and reduced-price NSLP lunches (81.4% in the sample compared to 79.4% statewide).

The remainder of the section summarizes findings from questionnaire responses and qualitative comments as it pertains to each research question.

Status of the Combi Oven Acquisition

The first research question of this study was to identify how many schools had functioning combi ovens at the time of the survey, and how the schools acquired them. Table 2 reports that, out of the 306 schools with an onsite kitchen, 229 schools (74.8%) obtained at least one functioning combi oven. They included 92 schools (30.1%) with one combi oven, 111 schools (36.3%) with two combi ovens, and 26 schools (8.5%) with three or more combi ovens.

Table 1. *Comparison of the Characteristics of Schools in the Sample to All Schools in Mississippi*

	Sample (<i>N</i> = 306)		All (<i>N</i> = 885)	Goodness-of- fit tests
	n	%	%	<i>X</i> ² test
<i>Grade levels^a</i>				
School serves Kindergarten	138	45.1	40.9	<i>N.S.</i>
School serves grades 1-5	180	58.8	56.6	<i>N.S.</i>
School serves grades 6-8	143	46.7	45.7	<i>N.S.</i>
School serves grades 9-12	93	30.4	38.6	<i>p</i> < .01
Title I school	265	86.9	70.3	<i>p</i> < .001
	M (SD)		M (SD)	t-test
Enrollment size	518.4 (293.2)		450.8 (339.0)	<i>p</i> < .05
Percent qualifying for free or reduced NSLP	81.4 (18.9)		79.4 (22.1)	<i>N.S.</i>

Notes: ^a Grade levels are not mutually exclusive categories because schools can serve multiple levels. *N.S.* = Not significant. Data from the National Center for Education Statistics, matched by the school identifiers.

Table 2. *Frequencies and Percentages of Combi Oven Implementation and Removal of Fryers (*N* = 306)*

Variables		n	%
Number of combi ovens at the school (<i>N</i> = 306)	None	77	(25.2)
	One	92	(30.1)
	Two	111	(36.3)
	Three or more	26	(8.5)
Number of funding sources ^a (<i>N</i> = 229)	One	169	(73.8)
	Two	45	(19.7)
	Three or more	15	(6.5)
Funding sources ^a (<i>N</i> = 229)	NIA ^b	86	(37.6)
	Federal funds	48	(21.0)
	District funds	116	(50.7)
	Local funds	11	(4.8)
	Other	43	(18.8)
Reason for not removing fryers (<i>N</i> = 306)	Removed or will be removed	247	(80.7)
	Needed for a backup	28	(9.2)
	Needed for catering/ events	21	(6.9)
	Other	10	(3.3)

Notes: ^a Percentages out of 229 schools with at least one combi oven obtained. ^b Nutrition Integrity Assessment grant. Funding sources are not mutually exclusive categories due to the utilization of funds from multiple sources.

Of the 229 schools that had a combi oven, 169 (73.8%) had only one funding source, 45 (19.7%) used two different funding sources, and 15 schools (6.5%) used three or more funding sources. It was not unusual that schools combined funds from multiple sources to obtain one combi oven. Further, only 86 schools (37.6%) out of the 229 schools with a combi oven reported using the NIA grant, leaving 143 schools (62.4%) that obtained their combi ovens without the NIA grant. Schools reported utilizing federal funds such as the NSLP or American Recovery and Reinvestment Act (ARRA) funding (21.0%), district funds (50.7%), local funds (4.8%), and other funds (18.8%) for obtaining a combi oven. Other funding sources included the school's internal discretionary funds, which were used in combination with grant funds. The availability of internal funds might have been related to the overrepresentation of Title I schools in the sample as they traditionally have larger general fund budgets.

Status of the Removal of Fryers

The second objective of this study was to explore the status of the removal of fryers at schools and uncover the reasons for non-removal. As shown in Table 2, the vast majority of schools in the sample ($n = 247$, 80.7%) reported either having removed or planning to remove all fryers in near future, whereas 59 schools (19.3%) still planned to keep one or more fryers in their kitchens. Schools keeping the fryers indicated that they still needed the fryer as a backup ($n = 28$, 9.2%) or for catering and other events held at the school ($n = 21$, 6.9%). None indicated lack of administrative support as the reason for not removing fryers. There were other reasons for non-removal ($n = 10$, 3.3%), some which had common themes. Two schools mentioned that they still incorporated fried items on the menu, and four other schools indicated they did not see enough value in changing their cooking method. In the qualitative interview, one respondent mentioned that they "feared that taking fried foods off the menu could lead to some students turning to competitive foods on campus or leaving campus for lunch to bring back fast food," consequently reducing participation in the school lunch program.

Infrastructure Challenges

Despite a desire to acquire combi ovens and remove fryers, many schools could not make the transition. The third objective of this study was to investigate whether the infrastructure inadequacy was an obstacle to implementing a combi oven.

Due to incomplete responses to infrastructure questions, the number of observations for Table 3 was reduced to 298. Respondents indicated that a majority of schools in the sample needed remodeling ($n = 177$, 59.4%), more physical space for storage, preparation, and serving ($n = 172$, 57.7%), and more plumbing capacity ($n = 152$, 51.0%). At a considerable number of schools, the need for more electrical capacity ($n = 145$, 48.7%) and ventilation ($n = 106$, 35.6%) was indicated. The need for additional natural gas capacity was indicated at the fewest number of schools ($n = 62$, 20.8%). To explore whether infrastructure challenges impacted the ability to install and implement a combi oven, we compared schools with a combi oven against schools without a combi oven. Two-sample t-tests suggest that schools without a combi oven were much more likely to need more physical space in the kitchen ($t = 2.65$, $p < .01$), more electrical capacity ($t = 2.01$, $p < .05$), and remodeling ($t = 2.03$, $p < .05$) than schools that had a combi oven.

Qualitative evidence gathered during the telephone interview supports the importance of adequate infrastructure for implementing a combi oven. According to the comments received, four schools would require "a major electrical reconfiguration of the kitchen" to accommodate a

piece of new equipment such as combi ovens. Fifteen schools already implementing a combi oven were also described as lacking “physical space to accommodate additional combi ovens”. Seven schools were described as lacking the plumbing capacity to support a combi oven as “combi ovens require a water line” for their steaming capability. Twenty-four schools were described as “unable to support additional equipment without reconstruction or remodeling” of production kitchens.

Table 3. *Frequencies, Percentages, and T-Tests of Infrastructure Needs by Combi Oven Status (N = 298)*

	All (N = 298)	Combi oven obtained (N = 223)	Combi oven not obtained (N = 75)	t-test
<i>In critical or moderate need for:</i>				
More physical space	172 (57.7)	119 (53.4)	53 (70.7)	2.65**
More electrical capacity	145 (48.7)	101 (45.3)	44 (58.7)	2.01*
More natural gas capacity	62 (20.8)	47 (21.1)	15 (20.0)	-0.22
More plumbing capacity	152 (51.0)	109 (48.9)	43 (57.3)	1.27
More ventilation	106 (35.6)	78 (35.0)	28 (37.3)	0.37
Remodeling	177 (59.4)	125 (56.1)	52 (69.3)	2.03*

Notes: Frequencies are reported with percentages in parentheses. N=298 due to incomplete responses for infrastructure questions. Two independent sample t-tests compares the schools with a combi oven obtained against those without. * $p < .05$, ** $p < .01$

Other Barriers

Aside from infrastructure challenges, respondents also discussed barriers with maintenance and staff acceptance of combi ovens. As older combi ovens began to require maintenance and repair, the financial burden, as well as varying availability of technical expertise for maintenance, caused frustration and service delay at schools that adopted combi ovens early. One comment stated “combi ovens are hard to maintain over the years and expensive to repair - requiring special labor and long hours to fix ...” This suggests that combi oven repairs often required specialized knowledge by the manufacturer that the maintenance workers on staff could not handle, which caused slower repairs and longer lapses in service than traditional equipment. In five schools, repair and maintenance of combi ovens were mentioned to be a barrier to the replacement or addition of new combi ovens.

Another issue the interview uncovered was insufficient staff training on how to use combi ovens and their many features. One response that applied to three schools indicated potential underutilization, stating that the combi ovens acquired by the CND were often not being used at schools because managers of school kitchens simply “did not know how to use them” and had not been adequately trained.

CONCLUSIONS AND APPLICATIONS

This study used a survey of CNDs in Mississippi to assess the status of a statewide equipment grant program that started in the mid-2000s to update kitchen equipment and eliminate fried foods from school meals. Specifically, the study summarized data gathered through

questionnaires and in-depth interviews to evaluate the successes and challenges in implementing combi ovens as a replacement for traditional fryers. While a growing number of Mississippi schools obtained combi ovens and removed fryers, a persistent number remained without a combi oven, necessitating an investigation into what might have been the barriers to implementing the change. Major insights gained from this study are summarized below.

First, the high rates of combi oven implementation (74.8%) and fryer removal (80.7%) indicate that the vast majority of schools welcomed the adoption of new food-production technology to resign conventional, unhealthy cooking methods. This is a positive sign, as students' appreciation for healthy, high-quality foods is placing greater demand on schools to update their kitchen equipment and infrastructure so that they can adopt healthier cooking methods, such as scratch cooking (Asada et al., 2017). Since the first introduction of combi ovens in 2006 through the NIA pilot program and subsequent provision of combi ovens that incentivized removal of fryers, schools and district CNDs competitively sought out opportunities both within and outside of the NIA grant over the years. The NIA program currently accounted for a minority (37.6%) of schools implementing combi ovens. Most schools autonomously drew from a variety of funding mechanisms to implement the change and found creative approaches to implement non-fried menu options. This finding is similar to a recent web-based survey in California, which showed that food service directors of California public school districts also relied heavily on funds from their district operating budget to support school kitchen equipment purchases (Vincent et al., 2020). The utilization of a broad array of non-NIA funding sources for combi ovens is a clear testament to a catalytic effect of a state-driven initiative planting a seed of change and innovation. On the other hand, however, the reliance on non-public, local funds could put low-resource schools and districts at a disadvantage and potentially work against the effects of public policies and programs that attempt to promote nutrition equity (Larson & Story, 2015). Future studies should look into whether there is an association between the schools' socioeconomic environment and the utilization of resources for child nutrition.

Second, despite the multifunctionality of combi ovens, which allegedly makes them an effective substitute for fryers, there exists a perception that there is demand for fried foods from the students and teachers, and complete removal of fryers might lead to a decline in NSLP participation. These findings are consistent with an early study by Giampaoli et al. (2006), which presented the concerns among CNDs in North Carolina that students' demand for less healthful food items would decrease participation in the NSLP if healthier meals were served. This perception still exists, even though a recent study suggests that students are beginning to desire more healthful food choices (Asada et al., 2017). Comments received during the interviews suggest that this perception may be related to insufficient information about combi ovens and the lack of staff training. This finding is similar to what Stephens and Byker Shanks (2015) stated in a systematic review, that effective training for school food service professionals would be a key to providing healthier yet appealing meals. Although this in part could be due to staff turnover since the combi oven installation packages include initial training, many child nutrition personnel may not have knowledge or comfort with the technical operational requirements that provide the higher quality production output. Retraining opportunities may need to be considered because turnover is inevitable and may increase due to the COVID-19 impact.

Third, the physical infrastructure of some school kitchens can make the adoption of new technology practically implausible. The analysis of this study suggests that schools without a combi oven tend to be more likely to need infrastructure changes than schools that already

obtained a combi oven, suggesting the possibility that infrastructure inadequacy might have been an obstacle for removing fryers and/or obtaining combi ovens. Limited space and kitchen layout, electrical capacity, and plumbing capacity were associated with the difficulty of obtaining or adding combi ovens. A successful replacement of production technology would require holistic planning for a new cafeteria location and/or a costly renovation.

Fourth, as some combi ovens from earlier years become older, schools and district CNDs have been experiencing the unexpected cost of maintenance and service lapse. The survey revealed that combi ovens required specialized servicing and proprietary parts that in-house maintenance personnel were unable to handle. Although manufacturer-provided user training and maintenance agreements were customary at the time of installation, the geographic location of schools and turnover in child nutrition program staff have impacted the use and maintenance of such a technologically advanced piece of equipment. This could potentially intensify the financial strain and frustration for the child nutrition programs and affect the perceived value of combi ovens.

These findings provide useful lessons for child nutrition programs in other states and federal policymakers, as the equipment needs at school kitchens have been documented nationwide (The Pew Charitable Trusts, 2013). Mississippi's NIA program demonstrated that support for replacement of equipment might be an effective policy device to incentivize the discontinuation of unhealthy cooking practices. Further, Mississippi's experience showed that a competitive grant program that ignited changes on a modest scale could stimulate a broader transformation of meal production methods and motivate the child nutrition programs to find other resources to implement the change. This model can be replicated in other states looking to promote an efficient change in child nutrition programs. Rural schools should be given special consideration when it comes to implementing these changes, as research suggests that these schools are more likely to experience infrastructure challenges, particularly as it relates to additional equipment requirements (Hoffman et al., 2018). The selection of sites to pilot the change can also be strategically determined considering that the availability of funds varies by schools' location and demographics (Chang et al., 2016).

On the other hand, these experiences also suggest that improving school nutrition production methods is more complicated than simply dedicating funds to purchase new equipment. Addressing these obstacles will be critical to the success of implementing the equipment and providing healthier meals to children. This study revealed the need for infrastructure updates of school kitchens was paramount in the majority of schools. Infrastructure deficiencies also created a significant barrier to implementing combi ovens. Technologically intricate equipment such as combi ovens may involve changes to overall kitchen infrastructures and commitment for long-term maintenance. The findings from this study indicate the need for future funding programs that offer funds to make infrastructure updates to facilitate implementation of equipment updates.

Findings also indicate that the value of industrial innovation that enables increasingly reliable and efficient food production technology at schools could be diminished by child nutrition staff turnover and difficulty maintaining the effective use of technology. Retraining of personnel would help maximize the usage of new equipment and increase the return on investment. Some best practices of school food service staff trainings would be relevant to equipment-related staff trainings (Stephens & Byker Shanks, 2015). These include developing positive relationships between trainers and food service staff; ensuring continued, long-term support from trainers after the initial training is over; and providing prolonged trainings over the span of several years to

improve sustained achievement of desired training outcomes. Applying these practices to improve staff training of combi ovens would increase the usage and enhance the value of combi ovens that are already in place in school kitchens, ultimately leading to the improved nutritional profile and appeal of school meals. In addition, other ideas to explore may include joint training of new employees across the districts by child nutrition program staff who have established comfort with the operation of combi ovens, routine maintenance and retraining through tele-maintenance and tele-education, and provision of ongoing training through a collaboration between manufacturers and state agency leadership. Research outcomes such as those reported by the NIA project help make industry partners and manufacturers aware of these issues and provide a path forward for even greater technological advancements.

LIMITATIONS

Unexpected school closures and contingency operations of school meal programs upon the COVID-19 outbreak resulted in an untimely termination of data collection. It reduced the response rate and resulted in a non-random sample, which may have influenced the findings. The sample omitted several larger, urban districts with more schools because they were likely to take longer to compile the data and respond. On the other hand, the sample may have overrepresented the more motivated schools to report their equipment needs. A follow-up study of the entire population of schools would improve accuracy.

Additionally, the study used the critical infrastructure needs reported by CNDs instead of an objective infrastructure assessment. CND characteristics may have influenced their depiction of the infrastructure needs. Information about the CNDs, such as their experience and job tenure, would have been helpful to explain subjectivity.

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