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ORIGINAL ARTICLE

A Behavioral Intervention Increases Consumption of a New Biofortified Food by School Children: Evidence from a Field Experiment in Nigeria

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Abstract

Children's diets can have major implications for a wide range of diseases and their development outcomes. In Africa, micronutrient deficiency remains a major challenge and affects the health and development of vulnerable populations, especially children. A major effort to combat micronutrient deficiency has targeted biofortification of staple foods, with greatest potential being registered in the enrichment of, among others, sweetpotato with beta carotene—a precursor for vitamin A. However, overcoming vitamin A deficiency is made all the more complicated by children's general resistance to unfamiliar foods. We report the results of a field experiment in Nigerian schools designed to use behavioral techniques to promote consumption of an unfamiliar food: the pro-vitamin A rich orange-fleshed sweetpotato. We find that children eat more, on average, when the sweetpotato is introduced alongside behavioral nudges such as songs or association with aspirational figures. These results appear to conform to results found in a developed country context.

Keywords Nigeria · Child nutrition · Sweetpotato · Vitamin A deficiency · Behavioral economics

Résumé

L'alimentation des enfants peut avoir des répercussions importantes sur un large éventail de maladies et sur leur développement. En Afrique, la carence en micronutriments reste un défi majeur qui affecte la santé et le développement des populations vulnérables, en particulier les enfants. Un effort majeur pour lutter contre la carence en micronutriments a identifié la biofortification des aliments de base, le plus grand potentiel étant l'enrichissement de la patate douce, entre autres, avec du bêtacarotène—un précurseur de la vitamine A. Cependant, il est d'autant plus compliqué de surmonter la carence en vitamine A que les enfants résistent généralement à tout

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aliment inconnu. Nous rapportons les résultats d'une expérience de terrain réalisée dans les écoles nigérianes visant à utiliser des techniques comportementales pour promouvoir la consommation d'un aliment inconnu: la patate douce à chair orange, riche en pro-vitamine A. Nous constatons qu'en moyenne les enfants mangent plus lorsque la patate douce est accompagnée de coups de pouce comportementaux tels que des chansons ou l'association avec des personnages qu'ils admirent. Ces résultats semblent corroborer les résultats obtenus dans un contexte de pays développé.

Introduction

Poor or inadequate diet is a major cause of poor health and premature deaths worldwide (Beaton et al. 1993; Holick and Chen 2008; Stabler and Allen 2004). Childhood diets are often seen as a key to combatting diet related health issues (Hawkes et al. 2015; Jones and de Brauw 2015). Diets also matter greatly for the growth and development of children, especially in the early years of their lives (Elmadfa and Meyer 2012; Low et al. 2017; Ruel et al. 2013). There are two primary arguments used to justify targeting children with dietary interventions. First, preferences and habits formed as a child are likely to have much longer-lived impacts (Branen and Fletcher 1999). Second, children often present a convenient group for intervention, as large numbers can be reached through school feeding programs (Story et al. 2008). This is true both in high-income (Story et al. 2009) and low/middle-income countries (Jomaa et al. 2011).

The particular changes in diet that are desirable can differ markedly among different countries, cultures, and income levels. In each case, however, significant barriers to changes in children's diets arise even after identifying the changes desired. For example, in 2010, the United States undertook a complete overhaul of the nutrition standards required in their national school feeding program (Vilsack 2012; Wootan 2012). While this new program created strict guidelines for improved nutrition, there was significant pushback on the part of the students (Turner and Chaloupka 2014) resulting in some lowering of the initially implemented standards, some observed increases in food waste (Amin et al. 2015), and some minor concerns about program participation (Turner and Chaloupka 2014). When it comes to child nutrition, you can lead a horse to the water, but the real challenge is to get the horse to drink.

Behavioral interventions have shown significant promise in providing children the motivation to both select (Hanks et al. 2016) and consume (Hanks et al. 2013) targeted foods. These interventions use simple behavioral techniques commonly found in the social psychology, behavioral economics, or marketing literatures. This behavioral approach has the apparent advantage of being relatively effective, while having a relatively low cost (Just and Wansink 2009). However, these techniques were primarily developed to address nutrition issues facing children in high-income countries (centering around preventing obesity and encouraging a better balanced diet). Using similar techniques in a low/middle-income country context presents two obvious challenges. First, the dietary targets are often very different (focused on micronutrient deficiency and hunger rather than overconsumption of specific foods). Second, the cultural norms that form the crux of many of these behavioral interventions may be very different in any particular low/middle-income country. In short, a priori, it is not at all clear that the same style of interventions would be culturally appropriate to effect the same desired types of dietary changes.

In this paper, we report the results of an experiment conducted during school lunch for 3rd and 4th graders in 20 schools in Nigeria. We primarily targeted children ages 8 to 10. In each school, orange-fleshed sweetpotato (OFSP) was introduced as part of the school lunch. Prior to the intervention, OFSP had not been available in the region and were therefore not part of the school lunch served by the State school lunch program. OFSP was selected as a target food due to its high levels of beta carotene, a precursor for vitamin A, hence its potential to combat vitamin A deficiency (VAD). VAD is an endemic problem in most low/middle-income countries including in the target population (Low et al. 2017; West 2002). This intervention was part of a larger effort to introduce the OFSP as a crop for cultivation by rural households in Nigeria. In addition to control schools, where the OFSP was introduced without promotion, schools were randomly selected to introduce the OFSP using a promotional performance, posters featuring an aspirational figure, posters featuring age-appropriate promotion of OFSP, or all three promotional methods. We find that children in schools featuring the promotional performance and the aspirational figure, or all combined, ate significantly more OFSP than the control or those receiving the age-appropriate message. Moreover, it appears that the additional OFSP consumed in the schools receiving the promotional performance and the aspirational figure does not come at the expense of consuming the remainder of their meal. Given these results can be confirmed in future studies, they will have important implications for the introduction of new foods or achievement of nutritional policy goals in developing countries worldwide.

The Study Context

Malnutrition is an endemic problem in developing countries including Sub-Saharan Africa. All these countries have high incidence of malnutrition, especially among rural children and women (Low et al. 2017). The most vulnerable populations in these countries tend to comprise children and women, mostly due to their lack of access to economic resources compared to men (Black et al. 2013). Malnutrition compromises cognitive and physical development in children under 5 years of age and is associated with high morbidity due to preventable childhood diseases such as diarrhea (Akombi et al. 2017; Jones and de Brauw 2015). In Nigeria, recent statistics show stubbornly high rates of malnutrition, especially in rural communities. Wasting and underweight, for example, increased in Nigeria during the 2003–2013 decade from 11 to 18% and 24% to 29%, respectively, while stunting remained at 37% of the population (National Population Commission (NPC): ICF International 2014). Recent statistics indicate that overall national malnutrition rate is about 30%, with prevalence of stunting, underweight, and wasting among children under 5 years of age being approximately 32%, 21%, and 9%, respectively (Ogundipe 2015).[1] A

[1] This can be found online at: https://www.vanguardngr.com/2015/08/malnutrition-nigerias-silent-crisis/.

prior study conducted in Osun State, the context of our research, found that more than 53% of the children in the State were malnourished, with a similar proportion suffering from severe stunting (Esimai et al. 2001).

Current efforts to fight malnutrition in developing countries emphasize the use of nutrition-sensitive agricultural approaches (Ruel et al. 2013; Shikuku et al. 2019). One such approach that has gained prominence in the development literature is the biofortification of major food staples with essential micronutrients (Bansode and Kumar 2015; Bouis et al. 2017; Pinstrup-Andersen 2013; Ram et al. 2016; Pingali and Sunder 2017). Biofortification aims to fight the endemic micronutrient deficiencies in developing-country populations, especially those that reside in farming communities. The targeted micronutrients include vitamin A, zinc, and iron. OFSP, developed to fight vitamin A deficiency, is one of the success stories of biofortifying food staples. Regular consumption of modest amounts (100 g, three time a week) of OFSP supplies the vitamin A needs of VAD vulnerable populations (Low et al. 2017).

The promise of biofortification, and OFSP, in combating VAD has resulted in an increase in projects that promote production, access, and consumption of the biofortified sweetpotato in Africa and Asia. Some of these projects use school gardening and elementary school feeding programs as entry points for stimulating adoption and consumption of OFSP by rural households. School gardens are seen as potential vehicles for tackling nutrition problems among school-age children (Roche et al. 2017). Other projects incorporate OFSP into school feeding programs as a vehicle for reaching the children's households. In both the school gardening and feeding programs, children are targeted as agents of change. However, questions remain about the most effective ways of increasing the acceptance of nutritionally enhanced biofortified foods, especially OFSP, among such children, and sufficiently stimulating them to perform the role of change agents. Hence, this study tested several strategies that can be used to shore-up the acceptance of OFSP using a field experiment involving elementary school children in rural Nigeria.

Background and Hypotheses

Related Behavioral Work and Context

A growing literature has examined the potential to use behavioral economics to influence the diets of school children. Much of this work has centered around the use of behavioral interventions in US schools participating in the National School Lunch Program (NSLP). Most prominently, this has been distributed to more than 20% of schools in the US under the name Smarter Lunchrooms (Gabrielyan et al. 2017). The program uses six basic behavioral principles (i.e., nudges) designed to encourage increased selection of targeted foods at very little cost to the school food service. These principles include: convenience, visibility, strategic portion size reference points, setting expectations, using suggestive selling names, and using smart pricing strategies (Just and Gabrielyan 2016). Each of these principles has deep roots in the social psychology literature, with more recent studies conducted in school environments. We focus most specifically on the principle of setting expectations. For example, Turnwald et al. (2017) find that using attractive names for targeted foods can lead to an increase in overall selection and consumption. Using these attractive names sets an expectation regarding the food and how it is likely to be perceived by the target audience. Restaurants engage this principle when they include descriptive words like “succulent” or “homemade” in the names of their dishes. Similarly, wrapping a salad bar with images of puppet characters can increase selection of salads quite dramatically (Hanks et al. 2016). This sort of promotion both draws attention to the food, but also sets an expectation that it is both fun and intended for a target age group. A combination of such behavioral interventions has been shown to increase fruit consumption in a sample of upstate New York schools by approximately 23% (Greene et al. 2017).

Setting can be used as a tool to associate foods with desirable characteristics or physical results. This is the case, for example, when foods are associated with celebrities (e.g., professional athletes and sports drinks) that lead consumers to associate athletic performance with the product (Bragg et al. 2013). Similarly, celebrities have been used in US schools to promote and associate better food choices with athletic performance (e.g., Irwin et al. 2010). In this context some have used creative names or other materials to associate fruits and vegetables with aspirational attributes (Thomas et al. 2016; Drzal et al. 2020). Such tools attempt to communicate the benefits of foods in form of a caricature/cartoon, using non-technical language that is appealing to children.

There are several unique challenges to promoting foods in Nigerian schools relative to schools in the US. First, techniques must be adapted to the cultural norms in Nigeria. While US children can be enticed with puppet figures or other familiar characters (Hanks et al. 2016), our formative work (described in more detail below) suggests that Nigerian school children do not have the same general familiarity with specific cartoon characters. Moreover, children in the US take a reference such as “x-ray vision carrots,” an example of age-appropriate communication, to communicate the health benefits of carrots in having good vision. These references do not appear to carry over to the children within the region of our study. For this reason, we have attempted to adapt this expectation setting approach for this specific context by engaging children in a song promoting OFSP, or by providing posters with widely known aspirational figures promoting OFSP, or other materials that communicate the advantages of OFSP in an age-appropriate way. Finding age-appropriate language is particularly difficult in this context given the wide age dispersion among students in classes where some may attend intermittently due to farm responsibilities and household chores. On occasion, more senior individuals may return to school having advanced significantly in age.

Finally, an additional important challenge is the prevalence and depth of food insecurity. While food security is a reality in US schools, very few students in prior study populations were affected by chronic food insecurity. For this reason, the impact of behavioral interventions on a food insecure versus a food secure child is not well understood. There is some reason to believe that behavioral nudges may be more effective when working with a food insecure population (Mullainathan and Shafir 2013). However, hunger may simply mean that children are willing to eat anything placed in front of them whether familiar or not. If behavioral interventions impact those who are facing chronic food insecurity, this would demonstrate the importance of seriously considering behavioral responses in food aid policy.

Hypotheses

From these considerations, we generate three main hypotheses and two ancillary hypotheses we wish to test through an experimental intervention. Our main hypotheses include:

H1: Engaging school children in a song that stresses how OFSP can promote health, strength, power, and success will increase the average consumption of OFSP.
H2: Displaying posters promoting OFSP using a known aspirational figure (in this case the soccer player John Obi Mekel) will increase the average consumption of OFSP.
H3: Displaying posters that use age-appropriate communication to stress that OFSP can promote strength, power, and success will increase the average consumption of OFSP.

For each of these main hypotheses we develop separate treatment arms of our study. In addition, we wish to test two ancillary hypotheses, namely:

AH1: Behavioral interventions can promote consumption among those who face food insecurity.
AH2: Behavioral interventions promote additional overall consumption.

These ancillary hypotheses will be tested using each of the three treatment arms separately to determine whether the indicated population is impacted.

Results from our analysis of those facing food insecurity should be considered with some degree of caution. The study was designed and powered to address hypotheses 1 through 3. Addressing AH1 requires cutting the sample to analyze only those who are food insecure. We had little information on how many children would report such insecurity a priori and thus present this as an ad hoc analysis.[2] The second ancillary hypothesis essentially wishes to establish whether we are promoting OFSP consumption through the reduction of other food consumption, or through additional overall consumption. Given the emergence of overweight and obesity in conjunction with food insecurity (Popkin et al. 2020), which has been documented within Nigeria (Alamu et al. 2020) and in Ethiopia (Wolle et al. 2020), it may be important in some contexts to keep calorie intake relatively stable (or perhaps to decrease overall calorie intake). In our study, however, we considered the effects

[2] This number can be highly variable throughout the year, making such power calculations difficult.

of under-consumption and stunting to be the primary target. Thus, we designed the intervention with the purpose to increase overall consumption, especially of OFSP.

Study Area and Population

The study was conducted in 8 local government areas (LGAs) in the Osun State of Nigeria from November to December 2016. The Federal Government of Nigeria in 2004 implemented the Home Grown School Feeding and Health program that provided at least one hot meal per day, during school week days, to elementary school pupils as part of a comprehensive strategy for the achievement of the Millennium Development Goals in Nigeria. The Osun State picked up and has continued to run this program at State level under the Osun Elementary School Feeding and Health Programme (O-Meals). The O-Meals program provides one mid-morning school meal to elementary school pupils in grades 1 through 4 in all its 1382 public primary schools. The program is designed to ensure that each child receives a balanced meal that provides a minimum of 33% of the recommended intake of key vitamins and nutrients (Shaad et al. 2010). Each school receives the same rotating menu of foods on the same day, creating both a good degree of internal consistency in our experimental design, and the potential for day of week effects.

The International Potato Center, Partnership for Child Development and the Osun State government partnered to pilot the introduction of OFSP into the O-Meals program as part of the routine menu. Thus, in January 2015, OFSP was incorporated into the O-Meals menu one day a week in the 8 pilot schools. Experiences from the pilot resulted in varying degrees of OFSP acceptance by students, raising questions as to appropriate strategies to introduce this healthy food into the school menu.

Experimental Design and Data

The current study was conducted in accordance with the guidelines laid down in the Declaration of Helsinki regarding procedures involving human subjects and was approved by the O-Meals State Program office and school authorities. The study was implemented in close collaboration with Partnership for Child Development (PCD), Osun State Education Board and O-Meals State Program Officer. The three agencies were involved in the design and provided inputs into the study protocols. Two weeks prior to the study, all legal guardians gave their informed consent to allow the research team to observe pupils' food choices and consumption in the school environment.

The study was conducted as a field experiment involving 20 elementary schools randomly drawn from the 8 selected LGAs where OFSP had not yet been included on the O-Meals menu. All the selected schools had therefore not been exposed to OFSP and were not serving OFSP as part of school meal prior to the study. The 20 schools were randomly selected, excluding schools that reported fewer than 28 pupil/enrollment in the target grades, and eliminating any draws that were geographically close enough to potentially cause cross-contamination. As part of the study,

Table 1 Number of participants in the study by treatment, school, and grade

Grade	Treatment/school number																			
	Control				Song				Asp. figure				Communication				Mixed			
	1	4	5	12	2	6	9	17	8	13	14	15	7	10	11	16	3	18	19	20
3	27	21	28	22	26	28	21	14	22	30	27	28	22	28	28	20	28	28	22	21
4	28	23	28	19	27	28	27	9	22	28	28	28	28	26	28	28	22	27	26	22

Note School names are blinded to ensure anonymity of participants. School numbers were assigned internally based upon order of random selection into the sample

School No. 17 had the smallest number of participants. This was because of absenteeism during the observation week due to events beyond the control of the researchers. Other cases where the participants were less than 28 was similarly due a participant missing at least one observation day during the 2 weeks of data collection. Common reasons for absenteeism were illness, farm work, and accompanying parents to market on market days

following baseline data collection, each of the schools would serve OFSP with their meals three times per week during a treatment period. The 20 schools were then randomly assigned to one of 5 treatment arms: (1) Control (introducing OFSP meal only), (2) Promotion (introducing OFSP meal and a song that associates OFSP with achievement in school), (3) Aspiration (introduction of OFSP meal in addition to an aspirational figure/character). The character was a famous world-class Nigerian soccer player, John Obi Mikel), (4) Age-appropriate communication (introducing OFSP meal in addition to giving the OFSP dishes a simple name that conveys their health properties), and (5) A combination of OFSP meal with the song and age-appropriate communication.

Within each treatment and control school, the study focused on grades 3 and 4 because they could better comprehend the information/instructions provided as part of the experiment. All the students in the selected grades participated in the experiment. For the grades with a large number of pupils, 28 pupils were randomly selected to participate in the study in order to keep the data collection manageable.[3] In such cases, cards with the different colors were used to distinguish the participants from non-participants. Specifically, cards with three different color codes were used: yellow for participants only, and blue and red for non-participants. The third color was purposely introduced to try to prevent students noticing the differences in between observation and non-observation groups. The students wrote their names on the cards and took it out and placed it next to the plate when lunch was served. The cards were left with plates as students proceeded to after-lunch recess so that the research assistants could identify participants' plates and the plate owner and record measurements. After the recording of observations, the O-Meals team proceeded to collect the plates for washing as usual, but the cards were kept by the students for the next observation day.

[3] A clerical error led to 30 participants at one school (see Table 1). There were also other schools where the target number of participants was not achieved due to absenteeism as explained under Table 1.

For the treatment 2 (OFSP meal + song) group, the pupils were led to sing and recite a rhyme that linked OFSP to good health and performance in school. Treatment 3 (OFSP meal + Aspirational figure) group had a poster of the soccer player displayed prominently in their classroom. Prior to serving the meals during each observational day, the research assistants provided a verbal narrative that associated OFSP with power, strength, and success that characterized the player. A similar approach was taken for Treatment 4, except that the aspirational figure was replaced by a poster associating OFSP with age-appropriate names. The poster was verbally discussed on each observation day prior to serving the meal. Lastly, Treatment 5 entailed the presentation of song and age-appropriate communication alongside the OFSP meal. The number of participants in each treatment arm is shown in Table 1.

There were two kinds of formative work performed in designing the study. In determining aspirational characters that could be used, researchers had informal discussions (i.e., key informant interviews) with teachers, PCD, O-Meals and project staff to refine the design and protocols, and with students in non-study, but similar, elementary schools during a small pilot/pretest. The research team, for instance, wrote the OFSP song jointly with O-Meals and project staff who spoke Yoruba language, the local vernacular, and selected the Aspirational character after wide consultations. The team then drew on knowledge from the small pilot study in the non-study schools to refine the song/rhyme developed about OFSP.

Prior to the start of the treatments, baseline data were collected at each school for four days spread out over a two-week period. That is, baseline data were collected two times per week for two weeks in each of the participating schools. This was followed by 6 days of observation, spread over two weeks, during which data were recorded three times per week (i.e., on Mondays, Wednesdays, and Fridays) for the different treatment arms. Thus, there were three observation days in each school per week. The intervening days (Tuesday, Thursday, and weekend—Saturday and Sunday) provided a break from consuming an OFSP meal to reduce likelihood of monotony.

The primary outcome variable in this study is food left uneaten. Research assistants recorded the observations using the plate waste method adapted from Hanks et al. (2014). Measurements were based on the amount of the O-Meals meal and OFSP meal left on the plate, reported in 10% increments. For each child, data were also collected on: age (years), gender (1 = male, 0 = female), grade (3 or 4), number of siblings (count), whether both parents live together (1 = yes; 0 = no), food poverty (i.e., child goes to bed hungry, 1 = never, 2 = sometimes, 3 = often, 4 = always), class performance (1 = high, 2 = medium, 3 = low), and mobile phone ownership by parent (1 = yes, 0 = no). A summary of the variable descriptions can be found in Table 2.

The distribution of ages by grade in these schools tends to be wide, as noted earlier. The vast majority of students are ages 8 to 10, but there are some as young as 5 and some as old as 15. Figure 1 displays a histogram of ages within our sample.

Table 2 Description of variables

Variable name	Definition	Frequency (%)	Mean (SD)
Gender	A dummy variable that identifies child's gender; 0 = female, 1 otherwise	46.84	
Age	A continuous variable that identifies child's age in years		9.31 (1.54)
Grade	A dummy variable identifying the grade level the child is in; 0 = 3^{rd}, 1 = 4^{th}	49.40	
Number of siblings	A count variable that identifies child's number of siblings; count		4.66 (2.08)
Academic performance	A categorical variable that identifies child's academic performance:		
	1 = high	37.55	
	2 = average	48.88	
	3 = low	13.57	
Parents live together	A dummy variable that identifies whether child's parents live together; 0 = no, 1 otherwise	29.23	
Parents mobile phone	A dummy variable that identifies whether child's parents have a mobile phone; 1 = no, 0 otherwise	8.45	
Went to bed hungry	A categorical variable showing the frequency of sleeping hungry:		
	1 = never	55.61	
	2 = sometimes	30.20	
	3 = often	6.84	
	4 = always	7.35	
Attendance	A dummy variable that identifies whether a child attended on a given observation day; 1 = attended, 0 otherwise	95.06	

SD standard deviation

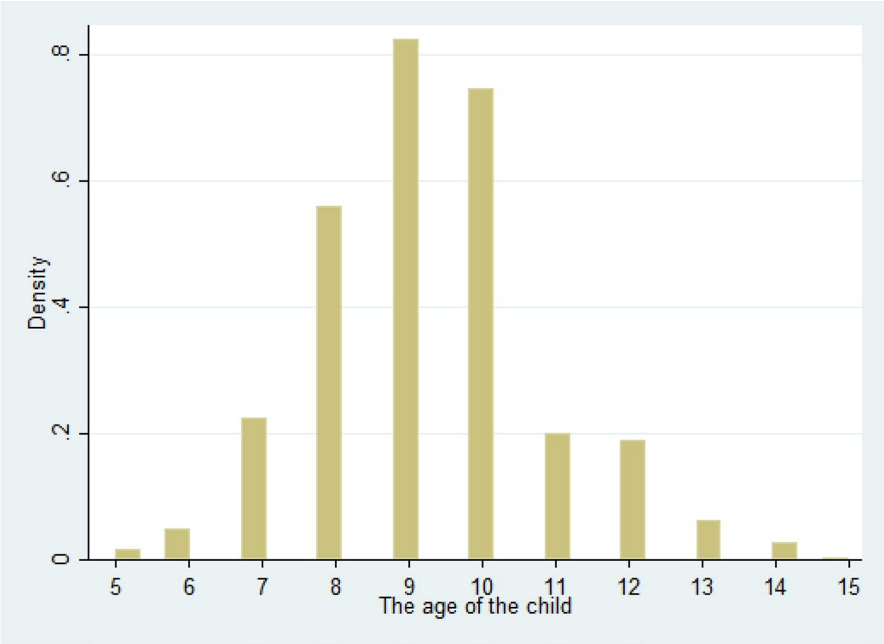

Fig. 1 Histogram of age within sample

The OFSP meal was served alongside, but in a separate plate from the normal O-Meals meal. The average weight of the OFSP meal (together with the plate) was 468 g, while the average weight of the normal O-Meal meal (plus the plate) was 313 g.[4]

The plate waste data collection approach allowed for the recording of information for a fairly large number of children during a relatively short period of time. Tracking which plates belonged to which student, using specific color coded cards with students' names written on them, enabled the research team to link waste measures with survey responses to demographic and other behavioral data. This approach does not, however, allow us to directly measure health outcomes. Nonetheless, increasing consumption of OFSP should indicate that children are closer to meeting recommended dietary guidelines.

Table 3 presents summary statistics for each of the socio-demographic variables by treatment and in aggregate. In general, most of the variation between treatments is not of a scale to be behaviorally important, though many differences are statistically significant. The largest differences are in variables that one would not a priori

[4] The OFSP meal was served on a single-use/disposable yellow plastic plate which were lighter than the metallic plates that were used by the O-Meals program even before the study. We opted to retain the O-Meals plates for all non-OFSP components of the meal so as to eliminate the possible influence of altering them on consumption behavior of O-Meals meal during the intervention.

Table 3 Variable definitions and descriptive statistics

Variable name	Control Frequency (%)	Song	Asp. figure	Communication	Mixed	Test Chi-square	*p* value
Categorical variables							
Gender	48.72	52.22	49.04	37.25	47.69	103.58	< 0.001
Grade	50.00	49.17	50.23	47.12	50.51	6.22	0.183
Academic performance							
1 = high	50.77	35.00	34.62	39.22	27.98	274.51	< 0.001
2 = average	38.97	53.89	50.96	48.04	52.85		
3 = Low	10.26	11.11	14.42	12.75	19.17		
Parents live together	27.69	30.00	19.71	33.33	35.90	152.37	< 0.001
Parents mobile phone	1.03	16.11	6.25	15.20	4.10	456.07	< 0.001
Went to bed hungry							
1 = never	46.63	52.22	53.37	58.82	66.67	569.69	< 0.001
2 = sometimes	34.72	42.22	26.92	25.49	23.08		
3 = often	8.29	5.56	7.21	5.39	7.69		
4 = always	10.36	0.00	12.50	10.29	2.56		
Attendance	97.30	92.82	93.76	97.12	94.13	70.27	< 0.001
Continuous variables	Mean (SD)					F test (*p* value)	*p* value
Age	9.64 (1.71)	9.04 (1.04)	9.09 (1.66)	9.15 (1.52)	9.64 (1.51)	76.46	< 0.001
Number ofsiblings	4.90 (2.01)	5.02 (2.28)	4.66 (1.88)	4.00 (2.08)	4.76 (2.00)	73.93	< 0.001

SD standard deviation, *Asp.* aspirational

p values are not adjusted for multiple tests presume would have substantial impacts on the acceptability of new foods (e.g., academic performance). Notably, there appears to be some variation in the percentage of students who report never going to bed hungry—a variable that would likely impact the acceptability of new foods. If hungrier kids are more accepting of new foods, we would thus expect uptake rates to be higher in the communication and combined treatment arms. For this reason, we control for observable differences in samples in our primary analyses. These potential differences provide an important limitation to some of our subsequent analysis.

In order to test our hypotheses, we estimate equations of the form:

$$y_{it} = \beta_0 + \sum\nolimits_{j\in \mathcal{T}} \beta_j D_{ij} + \sum\nolimits_k \gamma_k X_{ik} + \sum\nolimits_{t=2}^{6} \alpha_t Day_{it} + \epsilon_{it}, \quad (1)$$

where y_{it} is the amount of plate waste (that is, the amount food which was not consumed in percentage terms) for individual i on day t, D_{ij} is a dummy variable indicating if individual i was included in treatment j, X_{ik} are a set of individual specific demographic variables, Day_{it} are dummy variables indicating the day of observation, ϵ_{it} is a disturbance term, and β_j, γ_k and α_t are coefficients to be estimated. Treatments include:

$$\mathcal{T} = \{Song, Aspirational, Communication, Song + Communication\}.$$

Socio-demographic variables include controls for gender, age, academic performance, whether the student reports going to bed hungry, the number of siblings, and whether the student's parents live together and have a cell phone. We use two different methods to estimate the regression equations. Because there may be correlation in behavior at the school level, we cluster standard errors at the school level. In addition, we estimate two regressions using multilevel mixed-effects estimation (see Snijders 2011), allowing for the nesting of child within enumerator within school. This last set of regressions controls for child and enumerator specific variation as well as school effects. This regression is run with two different variations of control variables sets.

Results and Discussion

Students in each treatment left 30.49%, 18.13%, 17.17%, 34.00%, and 19.69% of the OFSP uneaten in the control, song, aspirational, communication, and communication and song conditions, respectively. On the face, this suggests that the song and aspirational figures may have led to an increase in consumption of the OFSP. However, because there may be some differences in student populations, it is important to control for socio-demographics and school effects. Table 4 presents the results of our regression analysis for OFSP plate waste.

In each of our models, the OFSP song is associated with leaving significantly less OFSP uneaten (between 12 and 14 percentage points less) providing some support for H1. Notably, the effect size is relatively similar even when controlling for whether the child reports going to bed hungry—perhaps the most obvious

Table 4 Coefficient estimates of various regression models for OFSP meal waste

Variable	Model 1 (cluster)	Multilevel mixed-effects linear models		
		Model 2	Model 3	Model 4
		Coefficient		
OFSP song	− 12.14***	− 12.96***	− 14.05***	− 14.31***
	(2.93)	(3.54)	(4.07)	(4.22)
Aspirational figures	− 12.23*	− 12.82**	− 13.40**	− 13.50**
	(6.61)	(6.32)	(6.71)	(6.72)
Age-appropriate communication	3.72	3.01	4.18	4.67
	(10.97)	(10.85)	(11.03)	(10.86)
Meal + Song + Communication	− 10.33*	− 10.72**	− 10.35**	− 10.17*
	(5.45)	(5.04)	(5.19)	(5.21)
Male			− 12.07***	− 11.84***
			(1.98)	(2.03)
Age			− 1.21**	− 1.17**
			(0.48)	(0.50)
Average academic performance				0.77
				(1.47)
Low academic performance				− 2.11
				(2.37)
Goes to bed hungry				− 0.21
				(1.51)
Parents live together				1.79
				(1.84)
Number of siblings				0.49
				(0.52)
Day 6		− 5.99*	− 5.85*	− 6.00*
		(3.28)	(3.26)	(3.24)
Day 7		− 1.68	− 1.54	− 1.79
		(5.03)	(5.04)	(4.97)
Day 8		0.13	0.33	0.19
		(4.51)	(4.49)	(4.47)
Day 9		− 1.92	− 1.69	− 1.81
		(4.20)	(4.19)	(4.19)
Day 10		5.12	5.23	5.15
		(4.74)	(4.74)	(4.76)
Constant	30.28***	30.79***	48.40***	44.43***
	(2.36)	(3.98)	(7.32)	(8.28)
	($n = 5421$)	($n = 5421$)	($n = 5375$)	($n = 5347$)

*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

Table 5 Coefficient estimates of various regression models for OFSP meal waste—hungry to bed

Variable	Model 1 (cluster)	Multilevel mixed-effects linear models		
		Model 2	Model 3	Model 4
		Coefficient		
OFSP song	− 8.75***	− 9.58***	− 10.33***	− 10.51***
	− 1.88	(2.63)	(3.12)	(3.27)
Aspirational figures	− 15.02**	− 14.38***	− 14.37**	− 14.04**
	− 5.50	(5.42)	(6.33)	(6.36)
Age-appropriate communication	12.45	7.85	10.59	11.86
	− 10.61	(11.57)	(11.36)	(11.12)
Meal + song + Communication	− 7.42	− 11.39**	− 10.49**	− 9.80**
	− 5.05	(5.21)	(4.70)	(4.60)
Male			− 10.62***	− 10.51***
			(2.72)	(2.75)
Age			− 1.37**	− 1.43**
			(0.66)	(0.70)
Average academic performance				− 2.05
				(2.78)
Low academic performance				− 1.82
				(2.84)
Parents live together				1.32
				(2.86)
Number of siblings				1.09
				(0.70)
Day 6		− 9.22**	− 8.93**	− 8.95**
		(4.12)	(4.04)	(4.05)
Day 7		− 2.57	− 2.29	− 2.54
		(5.57)	(5.57)	(5.51)
Day 8		− 1.89	− 1.42	− 1.49
		(5.35)	(5.29)	(5.28)
Day 9		− 4.01	− 3.56	− 3.55
		(5.14)	(5.08)	(5.09)
Day 10		3.21	3.45	3.46
		(5.59)	(5.61)	(5.62)
Constant	27.93***	31.10***	49.20***	44.52***
	− 1.48	(4.47)	(8.92)	(11.36)
	(n = 2417)	(n = 2417)	(n = 2371)	(n = 2366)

*$p < 0.10$; **$p < 0.05$; ***$p < 0.01$

of potential confounder in our randomization scheme. These effects are similar to the impacts of the use of aspirational figures (ranging from 12 to 13 percentage points), though aspirational figures result in slightly less significance (H2). In contrast, we find no evidence that age-appropriate communication reduced OFSP waste. Indeed, the coefficients for this treatment are all insignificantly positive. Thus, we have no evidence for H3. Combining the song and the age-appropriate communication also decreased OFSP waste, though significance is somewhat lower relative to the song alone (effects of 10 to 12 percentage points).

In Table 5, we repeat the analysis using only those who report going to bed hungry on occasion, in order to address AH1. We remind the reader of the caution necessary in interpreting these results due to the ad hoc nature of the analysis.

Recall that this sample ranges from approximately one third to one-half of each school's population. Again, we see that the song significantly decreased the amount of OFSP waste left in students' plates. While the significance is similar to the corresponding regressions with the general population, the size is somewhat smaller (8 to 11 percentage points). Alternatively, the size of effect of the aspirational figure relative to the control is nominally stronger (now 14 to 16 percentage points). The combination of the song with age-appropriate communication is also found to have a significant effect on leavings. Together, these results indicate that the behavioral interventions were effective for the population we might consider food insecure. Despite their risk of hunger, these children will not necessarily consume large quantities of any food placed in front of them. Rather, they, as others, respond to social and behavioral cues when determining how much they will consume (AH1). Perhaps even more surprising is the nominal evidence that age-appropriate communication perhaps had the opposite of the intended effect. Only one specification classifies this result as significant—and it is one that is prone to overstating significance. Nonetheless, there is a long literature demonstrating that nutrition education is often not as effective in encouraging consumption of healthy foods (Kent 2014) and can often have the opposite effect among children (McFarlane and Pliner 1997). This may also be an indication that our instrument was not successful in communicating the nutrition benefits in a way that was appealing to this age group. Though the evidence here is weak, it is interesting that this behavior (pushing back against nutrition information) could be observed in a low/middle-income country setting, and specifically among children facing food insecurity.

By way of contrast, Table 6 displays the corresponding estimates when considering only those who report never going to bed hungry.

The impacts of the song, aspirational figures, and the song combined with age-appropriate communication each significantly reduce OFSP waste. Though the differences are small, the magnitude of the estimated effects is nominally larger than that observed among those who report going to bed hungry. This suggests that the behavioral interventions are effective among both the food secure and the food insecure. Interestingly, the impact of the age-appropriate communication now has a negative sign (though, again, not significant). Thus, while the data are rather noisy for any strong conclusion, it appears that those who face hunger were more likely to push back on the nutrition communication than those who do not face hunger.

Finally, Table 7 displays the results of regression analysis of the impacts of our behavioral treatments on all O-Meal waste (including non-OFSP foods).

This analysis allows us to determine whether the behavioral interventions operated by causing students to substitute OFSP for other (i.e., O-Meals meal) food

Table 6 Coefficient estimates of various regression models for OFSP meal waste – never hungry to bed

Variable	Model 1 (cluster)	Multilevel mixed– effects linear models		
		Model 2	Model 3	Model 4
		Coefficient		
OFSP song	– 15.90***	– 17.09***	– 18.29***	– 19.02***
	(5.15)	(5.97)	(6.23)	(6.24)
Aspirational figures	– 10.59	– 12.97*	– 14.01*	– 14.55*
	(7.40)	(7.32)	(7.62)	(7.43)
Age-appropriate communication	– 3.52	– 2.50	– 1.72	– 2.06
	(11.04)	(11.25)	(11.82)	(11.42)
Meal + song + communication	– 13.42**	– 12.22*	– 11.47*	– 12.06*
	(6.21)	(6.27)	(6.68)	(6.62)
Male			– 13.05***	– 12.83***
			(2.20)	(2.29)
Age			– 1.12*	– 1.09*
			(0.61)	(0.61)
Average academic performance				2.97*
				(1.78)
Low academic performance				– 2.18
				(3.71)
Parents live together				1.54
				(1.88)
Number of siblings				0.18
				(0.47)
Day 6		– 3.42	– 3.43	– 3.66
		(3.40)	(3.41)	(3.40)
Day 7		– 0.97	– 0.96	– 1.20
		(5.10)	(5.10)	(5.06)
Day 8		1.73	1.69	1.5
		(4.46)	(4.46)	(4.41)
Day 9		– 0.26	– 0.24	– 0.47
		(4.16)	(4.17)	(4.14)
Day 10		6.69	6.68	6.54
		(4.82)	(4.83)	(4.85)
Constant	33.09***	32.23***	49.35***	46.45***
	(3.70)	(4.78)	(8.18)	(8.37)
	(n=3004)	(n=3004)	(n = 3004)	(n=2981)

*p<0.10; **p<0.05; ***p<0.01

served under the O-Meals program, or by increasing overall consumption of food in general. Because we can observe overall waste (for O-Meals meal) both before and after treatment, we can now use the traditional difference-in-differences approach,

Table 7 Coefficient estimates of various regression models for O-Meal waste

Variables	Model 1 (cluster)	Multilevel mixed-effects linear models		
		Model 2	Model 3	Model 4
		Coefficient		
OFSP song	− 0.15	− 0.76*	− 0.79*	− 0.79*
	(0.13)	(0.44)	(0.46)	(0.48)
Aspirational figures	0.30	− 0.82***	− 0.80**	− 0.80**
	(0.30)	(0.30)	(0.32)	(0.34)
Age-appropriate communication	− 0.01	1.84	1.90	1.95
	(0.19)	(2.45)	(2.50)	(2.57)
Meal + song + communication	0.00	1.09	1.12	1.07
	(0.17)	(1.02)	(1.02)	(1.03)
Male			− 0.43*	− 0.40*
			(0.23)	(0.24)
Age			0.02	0.02
			(0.15)	(0.16)
Average academic performance				− 0.23
				(0.18)
Low academic performance				0.21
				(0.45)
Goes bed hungry				− 0.17
				(0.21)
Parents live together				− 0.04
				(0.16)
Number of siblings				0.04
				(0.07)
Time dummy	2.31***			
	(0.31)			
Diff-in-diff (song)	− 0.92			
	(0.72)			
Diff-in-diff (figure)	− 2.00***			
	(0.64)			
Diff-in-diff (communication)	3.35			
	(4.32)			
Diff-in-diff (all at once)	1.55			
	(1.49)			
Constant	0.22*	− 0.12	− 0.10	− 0.10
	(0.11)	(0.68)	(2.04)	(2.13)
	($n = 9440$)	($n = 9440$)	($n = 9344$)	($n = 9295$)

$^{*}p < 0.10$; $^{**}p < 0.05$; $^{***}p < 0.01$

providing much stronger control for non-observable differences in treatments. The coefficients for those in the song treatment indicate that students cut their consumption of the O-Meals meal somewhat less than 1 percentage point (significant at the 0.10 level). This size effect is small relative to the impact on OFSP consumption. O-Meals meal contained 188 g of food on average, thus reduction of 1% is approximately 2 g of food. Alternatively, OFSP was served in quantities of 443 g, thus students in these treatments increased their consumption of OFSP by something greater than 44 g. Similar magnitude of impacts is found for aspirational figures (as high as 1.5 percentage points). Thus, while there appears to be some small amount of tradeoff on the margin, the bulk of the effect of these behavioral interventions was by creating additional consumption (AH2). No significant impacts on O-Meal consumption were found for either the age-appropriate communication, or the song and communication treatments. Running these same regressions for those facing hunger yields similar results.

Conclusion

This manuscript presents the results of a series of behavioral interventions in a Nigerian school lunch program designed to encourage the consumption of OFSP. We find evidence that behavioral interventions that engage the students in song or use aspirational figures (in this case, a professional soccer player) are effective in encouraging additional OFSP consumption, with increases on the order of 47 g or more. This result was observed both among those who face substantial food insecurity and those who do not face food insecurity.

One of our behavioral treatments, that involving age-appropriate communication of nutritional benefits, had no significant impact, and most often was associated with reducing consumption of OFSP. There are many reasons this could have happened. It could be that this strategy is not effective among this population generally, despite findings in high-income country contexts where it has been found to be effective. Perhaps more likely is that we were unsuccessful in finding words and images that were appropriate and that successfully found ways to connect with children. Indeed, the indications in the data that those facing food insecurity in particular resisted this treatment seem to mirror the work in high-income countries demonstrating reactance among children when they feel that nutrition policy is too heavy-handed (Schwartz et al. 2017). The potential for such reactance in the face of food scarcity underscores the necessity of finding effective behavioral strategies in food aid and among food insecure.

Finally, there are several limitations to our analysis that must be acknowledged. Because we are introducing a new food, we rely heavily on randomization at a school level rather than the more powerful difference-in-differences approach that can be used for foods that already exist within the menu of items. For this reason, we have introduced several controls within our analysis for observable differences in treatments and have specifically focused on indicators of food insecurity. In addition to this, due to funding and staffing constraints, we were only able to implement our intervention for two weeks. It is unclear whether the results of this study are simply due to the novelty of the behavioral interventions that may wear off after some time. Future studies are needed to both confirm our findings and to explore their robustness. These studies should use longer intervention periods to determine the sustainability of the effects and whether the effects continue after the behavioral interventions are withdrawn. Additionally, this study was conducted during a time of the year that is typically associated with greater food insecurity. It is unclear whether the results would be stronger or weaker in times of plenty.

The use of behavioral interventions to encourage food consumption is a topic of growing interest in a wide variety of contexts. While we have demonstrated feasibility in a low/middle-income country context, much work remains to be done to ensure that such approaches are effective and profitable within this context. This work will likely require significant cooperation with local populations to determine the appropriate cultural cues and norms on which to base behavioral interventions. Moreover, it will be important to determine how reactance and other potentially unintended consequences can be triggered among target populations, and specifically how these effects may be related to food insecurity.

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Compliance with Ethical Standards

Conflict of interest The authors declare that there is no conflict of interest in the study.

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