Exploring Behavioral Nudges to Improve Nutrition in Bangladesh[*]

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Selected Paper prepared for presentation at the 2017 Agricultural & Applied Economics Association Annual Meeting, Chicago, Illinois, July 30-August 1

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[*] *This research was generously supported by the United States Agency for International Development (USAID) and US Government Feed the Future project "Integrating Gender and Nutrition within Agricultural Extension Services" (INGENAES). The contents are the responsibility of the authors and do not necessarily reflect the views of USAID or the United States government.*

I. Introduction

In Bangladesh, rice is the most commonly consumed staple crop, providing up to 70 percent of energy intake for an individual's diet (Torlesse et al., 2003). Contrary to Bennett's Law, which says an increase in income will lead to a decrease in the consumption of starchy staples, the demand for rice in Bangladesh has a positive income elasticity, $\varepsilon_Y = 0.65$ (Islam et al., 2007). Households across the country consume similar food baskets, with rice being the prominent food item, regardless of income or poverty level (Rabbani, 2014). Because the crop is so widely consumed, the strategy for food security in Bangladesh is to achieve self-sufficiency in rice production (Hossain, 2005; Rashid et al., 2011; Thorne-Lyman, 2010). With 70 percent of total cropped area planted to rice, the country has almost achieved its goal of self-sufficiency in rice production (Ahmed et al., 2013). However, the nation still faces malnutrition challenges. In Bangladesh, 33 percent of children under age five register low weight-for-age, known as wasting, and 36 percent of children under age five are stunted or have low height-for-age (World Bank, 2016).

While the access and affordability of food has increased in Bangladesh, the nation continues to battle undernourishment, largely due to dietary deficiencies of micronutrients, such as vitamin A and iron, from a lack of dietary diversity. A number of studies have shown dietary diversity, the consumption of a number of different foods or food groups, improves nutrient adequacy and reduces malnutrition (Arimond and Ruel, 2004; Hatloy et al., 1998; Rah et al., 2002; Ruel, 2002; Torheim et al., 2004).

In an effort to encourage dietary diversity and improve maternal and child nutrition in Bangladesh, the SHIKHA project, a USAID initiative facilitated by FHI360 and BRAC, developed a pictorial diagram of proper meal portioning, similar to the United States Department of Agriculture (USDA) MyPlate. The diagram, printed on a plate, was designed as an educational tool to be used by community health and nutrition workers when meeting with pregnant and lactating women. We will refer to this plate as the Bengali portion plate (BPP). In 2016, the Bangladesh Ministry of Health and Family Welfare formally adopted the BPP for use in their nutrition education efforts (USAID SHIKHA Project, 2016). Using colorful illustrations and images of locally prepared food the plate portrays information to encourage dietary variety, proper portioning, maternal nutrition, and hand sanitation, while informing users about the types of food that constitute key food groups of a healthy diet (see panel a of figure 1). The key message of the plate is to consume “a half plate of rice and at least four other varieties of food” (USAID SHIKHA Project, 2015).

In a behavioral economics experiment using meal observation and survey data, this paper investigates whether the BPP can be used as a more general tool to encourage Bangladeshi citizens, male or female, to make healthier food choices and consume a more diverse diet. Several organizations in Bangladesh are planning to use the BPP in their nutrition programs, some of which emphasize agricultural interventions (USAID SHIKHA Project, 2016). Thus, this study specifically targets households in rural Bangladesh to evaluate the effectiveness of the BPP as an intervention for combatting micronutrient deficiencies by improving dietary diversity in agricultural communities. The evidence-based results from this field experiment will inform government and non-government agencies in Bangladesh about the effectiveness of the BPP, and the methods used in this study can be replicated to pilot-test nutrition-sensitive agriculture programs in other developing countries.

The BPP is similar to the USDA MyPlate in that it uses a simple diagram to educate people about the national guidelines for nutrition. The MyPlate initiative was developed by the

USDA to convey proper food group portions according to the 2010 Dietary Guidelines for Americans (USDA, 2016). In 2011, the MyPlate replaced the Food Pyramid representation used throughout the 1990s and 2000s to promote a balanced diet in the United States (Brown et al., 2014). In the US, the risk of obesity and other food-related health problems is higher among food insecure households, and subtle cues, referred to as nudges, embedded in food assistance policies could encourage individuals to make healthier choices (Just et al., 2006). Thus, many behavioral economics studies conducted in the US focus on nudging individuals toward healthier food choices in an effort to decrease the incidence of obesity and chronic diseases caused by poor nutrition and excessive calorie intake.

Recent studies have found MyPlate messaging can effectively change behavior by encouraging healthier food choices (Miller et al., 2016; Brown et al., 2014). In a study of elementary and middle schools enrolled in the National School Lunch Program, Miller et al. (2016) find students are 27.7 percent, 15.8 percent, and 16.3 percent more likely to select fruits, vegetables, and low-fat milk, respectively, when pre-ordering their lunch in the morning using a computer program. The study shows even larger increases in the selection of fruits, vegetables, and low-fat milk of, 51.4 percent, 29.7 percent, and 37.3 percent, respectively, when students are prompted with MyPlate messages during the pre-ordering process. Brown et al. (2014) finds similar results – exposing college students to the MyPlate via text message increases the consumption of fruits by 13 percent and vegetables by 8 percent compared to the control group. A study by Wansink and Kranz (2013) finds families who regularly eat vegetables believe that adopting MyPlate guidelines will help them eat better; the authors also find the adoption of MyPlate to guide family nutrition decisions is highest among people who are already familiar with the USDA food pyramid.

These USDA MyPlate messaging studies contribute to a larger body of literature on the use of behavioral economics interventions to promote healthy eating habits in the US (Hanks et al., 2012; Just et al., 2007; Just and Payne, 2009; Thorndike et al., 2014). Collectively, these studies suggest the use of behavioral economics interventions, or nudges, can effectively encourage consumers to make healthy food choices. A nudge is a subtle cue that influences an individual's behavior without removing that individual's freedom of choice (Thaler and Sunstein, 2009). In the case of encouraging improved nutrition, a nudge could be the introduction of a nutritional information image like the MyPlate, conveniently packaging healthy food items, or changing the choice architecture, arranging food items in a way that encourages the selection of healthier options. In the US, it has been argued that findings from behavioral economics and food psychology research could be used to inform food policies, especially for programs designed to combat obesity (Just et al., 2006; Just et al., 2007; Just and Payne, 2009). Our research aims to apply similar techniques to nudge participants in developing countries toward healthier choices to combat malnutrition.

Banerjee and Duflo (2011) discuss the use of nudging in development economics to encourage behavior change. The authors suggest nudges may be especially effective in the case of preventative care, when organizations are promoting activities for which households do not receive immediate reward, but which will receive the pay off in the future (i.e. bed nets to prevent malaria). Nudges can help change behavior when households are skeptical of the proposed benefits (Banerjee and Duflo, 2011). In the case of nutrition, many of the benefits of adopting healthy choices may only be realized in the future such as a decrease in child malnutrition, increased labor productivity, improved cognitive development, increased educational attainment, and reduced costs of medical care (Belli et al., 2005). While several studies have examined the use of behavioral economics in nutrition and food policy in the developed world, the application of behavioral economics to combat malnutrition is just starting to gain traction in low-income economies. The World Bank recently launched a set of behavioral economic experiments in Madagascar to nudge women toward purchasing healthier food (Rutter, 2016).

Our study explores the potential for nudging households in developing countries toward healthier food choices to improve nutrition. Applying methods used in behavioral economics and nutrition research in the US, we investigate whether the BPP can nudge individuals in rural Bangladesh to diversify their diets such that a higher portion of their calories come from foods rich in vitamins and nutrients instead of rice. Using a randomized controlled trial experiment this paper evaluates the effectiveness of the BPP at encouraging dietary diversity when participants are exposed to the plate during a buffet meal. Wansink and Kranz (2013) find that many early adopters of MyPlate were already familiar with the previous food pyramid, and thus suggest training and practical guidance when introducing a nutrition icon to new users. Therefore, in addition to the BPP intervention, our experiment includes a second set of treatments, nutrition education in a participatory workshop. This paper analyzes meal observation data to measure the impact of the portion plate alone and when it is combined with nutrition education. The results show that the plate alone has no impact; however combining the BPP with participatory training on nutrition is an effective strategy for encouraging dietary diversity.

II. Experimental Design

To facilitate the recruitment of participants, we partnered with the Bangladesh Agricultural University (BAU) and Shushilan, a local NGO. The research was conducted in two project areas where the Bangladesh Agricultural University Extension Center (BAUEC) and

Shushilan work with rural households to improve their livelihoods through agricultural extension services. For the purpose of this research we engaged Shushilan beneficiaries from the "Managing Natural Resources by the Coastal Community" (MaNaR) project since those households had not received prior nutrition training. The project locations were in the Mymensingh and Borguna districts, the beneficiary sites for BAUEC and Shushilan MaNaR, respectively. Mymensingh is located in the northern part of Bangladesh, while Borguna offers a stark contrast in southern Bangladesh. The BAUEC farmer membership is 55 percent male and 45 percent female and spans across 20 unions in one upazila[1]. The beneficiary roster for MaNaR is 94 percent female and 5 percent male, and the project encompasses three unions in one upazila. Our target number of participants totaled 1,200 participating in two meals each, for a total sample of 2,400 meal observations. Stratifying by location, we targeted 600 randomly selected participants from each district. The sample included 18 communities in the Sushilan project area and 35 communities in the BAUEC project area, where the communities are smaller.

Following a fully factorized randomized controlled trial (RCT) design, participants were randomly assigned to a combination of two interventions 1) exposure to the BPP and 2) nutrition education. To implement the experiment, all participants were invited to the field office of the respective partner organization on two occasions for a meal and potentially a nutrition workshop depending on the participant's treatment assignment. All participants were invited to attend two buffet meals approximately one month apart. Each meal was served at 1:30pm, the typical lunch hour in Bangladesh. Ten food items corresponding to the BPP food groups were arranged in a buffet line: rice (cereals), chicken (meat), fish, mixed vegetables (white potatoes and tubers; orange vegetables), leafy green vegetables, cucumber and onion salad (other vegetables), dal

[1] An upazila is equivalent to a county-level administrative area; a union is the sub-county level comprised of a cluster of villages

(lentils), boiled eggs, bananas (fruit), and yogurt (dairy). A chef was hired in each study location, and all dishes were prepared in the same fashion each meal, according to local cuisine. The items were arranged in the same order in both locations for each meal, and the menu remained the same over the course of the study. During each meal, enumerators discretely observed individuals' food choices as participants served themselves from the lunch buffet. Participants were encouraged to take as much food as they desired. As previously stated, each participant was invited to two meals. Individuals assigned to the plate treatment used the BPP during one of the two meals, while the control group used a regular plate without the BPP diagram at both meals. All of the plates used in the experiment, both the regular plate and the BPP, were made of melamine, equivalent in size, and were ordered from the same factory. The plates have the same background color, however the BPP was printed with the proper portioning diagram and the regular plate was printed with flowers (see figure 1). The flower print pattern resembles a standard plate commonly used in Bangladesh. The education treatments were implemented through a participatory workshop prior to the lunch buffet.

Participants assigned to plate treatment A used a regular plate for both buffet meal observations and were never exposed to the BPP; hence these participants serve as the control for the plate intervention. Participants assigned to plate treatment B used a regular plate during the first meal observation and the BPP in the second meal observation. To achieve the fully factorized design, participants assigned to plate treatment C used the BPP in the first meal observation and a regular plate in the second meal observation. Participants assigned to plate treatments B and C were given BPPs to take home, one for each family member in their household, after the meal in which they were first exposed to the BPP. To reduce potential spillover effects and contamination that would occur if participants receiving the BPP showed the plate to participants in plate treatment A, the plate intervention was randomized at the community level with all participants in a particular community assigned to the same plate treatment (A,B, or C).

In addition to the plate intervention, individual participants were randomly assigned to one of three nutrition education treatments 1) no nutrition education, "None", 2) nutrition education, "N", or 3) nutrition education with an additional gender component, "NG". The education treatments were assigned at the individual level, and participants received the same training assignment, if any, at both meal events prior to being served the meals. The nutrition and gender education interventions followed a participatory workshop design, conducted by facilitators who were trained to follow the workshop methods described in the INGENAES Introductory Workshop on Integrating Gender and Nutrition within Agricultural Extension Services Facilitator's Guide (Henderson, 2016). Specifically, the nutrition education component followed the "What Goes on the Plate" activity, where small groups illustrated and discussed the components of a healthy diet. The session concluded with a presentation of the national food-based dietary guidelines, which correspond to the messages on the BPP, however the facilitator did not introduce the BPP during the training. The gender component of the nutrition education intervention implemented the "Who Gets What to Eat" exercise from the facilitator's guide, a role-play activity on intra-household food distribution to facilitate a discussion on women's nutrition and the cultural norms surrounding intra-household allocation of food.

Participants who were assigned to the education control group, "None", did not receive nutrition training, and they were invited to come to the research site at 1:00pm, after the participatory workshop was finished. Individuals assigned to the "N" and "NG" education treatment groups arrived at the research site at 10:00am and participated in the same nutrition education session, the "What Goes on the Plate" activity. Individuals assigned to treatment "N" received this training only and were then asked to leave the training room for a break. Individuals assigned to treatment "NG" stayed for the gender component of the training, the "Who Gets What to Eat" activity. On the day of the workshop, the treatment groups were denoted by colored nametags, prepared in advance by the facilitators. The workshop concluded at approximately 1:00pm, and all participants from the three treatment groups were invited to eat the buffet meal at 1:30pm, where enumerators discretely observed participants' food consumption. Individuals received the same assigned education treatment and followed the same schedule for the second meal observation one month later. The nutrition trainings were repeated because frequent exposure to nutrition messages reinforces the information (Brown, 2014).

Table 1 outlines the combination of the three plate treatments and the three education treatments randomly assigned to participants. Group 1 serves as the pure control group; participants in this group were not exposed to the BPP at either meal observation and received no nutrition education.

The fusion of behavioral economics strategies, using the BPP as a nudge, with behavior change communication through participatory training is a unique approach to nutrition interventions in agricultural development. This multifaceted experimental design allows us to evaluate the impact of the BPP alone and when it is combined with participatory training.

The data collection for this study included a baseline survey, the field experiment incorporating the two meal observations, and a short post-meal survey following each meal. The baseline survey was conducted as a face-to-face interview at the respondent's home by trained enumerators and was conducted in Bengali, the national language. The baseline questionnaire, which included a household roster, elicited information about demographics, agricultural production, 24 hour and 7 day frequency of food groups consumed, market access, household food insecurity, and nutrition knowledge. The baseline survey took place at least one business day prior to the participant's first meal observation. The survey enumerator invited the participant to attend two meals and the nutrition workshops (if applicable) as compensation for his or her time spent completing the survey. The participant was given two meal tickets with the dates, location, and time to arrive for the meals. The meals served as partial compensation for the participants' time, but also provided an opportunity to collect meal observation data. Participants were also given a small monetary stipend to cover their transportation costs to the field office at the end of each meal.

To collect meal data, enumerators recorded the amount of each food item a person took from the buffet and also documented the amount of waste of each food item left on the plate at the end of the meal. These two values were used to calculate the consumption of each food item. A hidden food scale was placed under the serving dish for rice to measure the amount of rice taken. Other food items were measured using visual inspection of standardized spoonfuls; enumerators counted the number of spoonfuls, in quarters of spoonfuls, of each food item taken by a participant. Prior to each meal, enumerators weighed and agreed upon a standardized spoonful for each item. Plate waste was measured using the quarter-waste method for visual inspection of remaining food items in terms of standardized spoonfuls. Hanks et al. (2014) validate the quarter-waste method as an accurate, reliable and cost-effective method of visual measurement to measure plate waste; we expand on Hanks et al. (2014) by also using the method to measure food item selection.

By inviting each participant to two meals, we observed individual preferences and eating patterns, which was particularly important since the participants were not accustomed to selecting food from a buffet. Essentially, the two meals allowed us to use each participant as his or her own control. After the participant finished eating, he or she completed a short post-meal questionnaire about 1) how hungry he or she was before the meal and 2) whether he or she disliked any of the food items on the buffet. At the second meal observation, the post-meal questionnaire also included the four-week household food insecurity questions to account for the fact that more than four weeks had passed since the baseline questionnaire.

III. Empirical Model

Using the meal observation data and the baseline survey data, this paper estimates the treatment effects of the BPP and the nutrition education interventions on meal diversity. We are primarily interested in whether the interventions nudge participants toward a more diverse plate of food. Thus, we construct an outcome variable to measure the individual's meal diversity, which we will refer to as the meal diversity score (MDS). The meal diversity score is modeled after the Simpson's index, which is commonly used to measure biodiversity and which has also been applied to farm diversity (Jones et al., 2014). Rather than measuring the diversity of crops within a fixed area of land, however, we construct an index to measure the diversity of food items consumed. The meal diversity score, MDS is defined as $1-\sum_{j} p_{ij}^{2}$ where p_{ij} is the portion, or share, of the individual's plate allocated to food item j. The portion is calculated as $p_{ij}=\frac{w_{ij}}{W_{j}}$ where w_{ij} is the weight (kg) of food item j consumed by the individual, *i,* and W_{i} is the total weight (kg) of the individual's food consumption, including all food items, $j=1,2,\ldots,J$. MDS takes a value between [0,1], where a smaller number represents low meal diversity and a larger number represents high meal diversity.

Our experimental design included repeated measures, where participants were observed during two meals. When an individual participates in the same experiment twice, bias may arise. We counterbalanced the order in which the individuals in plate treatments B and C were exposed to the nutrition messaging plate, during meal 1 or meal 2, in attempt to remove the potential bias from repeated measures. We test for order effects to determine whether the counterbalanced design successfully eliminated bias from repeated measures. Specifically, we calculate the mean difference in MDS when participants are exposed to the BPP (MDS_{BPP}) versus the regular plate ($MDS_{Regular}$). To verify the absence of order effects, we use a paired t-test to ensure the mean difference in MDS_{BPP} and $MDS_{Regular}$ is not statistically significantly different for participants in plate treatment B versus C. If the test indicates that there are not any order effects, the observations from both meals can be pooled and the effects of the BPP can be tested using a simple linear regression. Pooling the meal observations reduces our treatment and control groups to six combinations, presented in table 2.

The following equation represents the model to test the impacts of the nutrition education and BPP interventions on the meal diversity score for individual *i* during meal *m* assuming that order effects are not present.

$$(1)\quad MDS_{im} = \beta_0 + \beta_1 plate + \beta_2 N + \beta_3 NG + \beta_4 plate * N + \beta_5 plate * NG + X_i' \beta_n + \varepsilon_i$$

Plate is a dummy variable that takes the value of 1 if the individual was given the BPP to use during the meal observation and received no nutrition education. *N* and *NG* are dummy variables indicating whether the individual received nutrition education or nutrition education with a gender component, respectively. The estimated value of β_1 represents the effect of the BPP nudge on *MDS* when the participant is nudged by the plate alone, β_2 is the impact of nutrition education on *MDS*, and β_3 is the impact of nutrition and gender education on *MDS*. Through interaction terms, β_4 and β_5 measure the combined effects of the BPP nudge with the nutrition or nutrition and gender education, respectively.

The model also includes district-level, household-level, and individual-level explanatory variables contained in X_i. We control for the district where the participant lives using a dummy variable equal to 1 for the Mymensingh district and 0 if the participant lives in the Borguna district. The district covariate captures general differences in socioeconomic status, tastes, and preferences between the two geographical districts. At the household-level we include covariates for household monthly income, poverty scorecard index, household food insecurity access score (HFIAS), and farm diversity to control for exogenous factors that affect food preferences and familiarity with various food items. Household monthly income is a continuous variable measured in the local currency, Bangladeshi Taka (BDT[2]). The poverty scorecard index follows Schreiner (2013), taking a value from 0 to 100, to quantify the likelihood that household expenditures are below the national poverty line for Bangladesh. A lower poverty scorecard index represents a higher likelihood that a household falls below the poverty line. The household food insecurity access score (HFIAS) is a continuous variable measuring the frequency of food insecurity of a household in the last 30 days. Specifically, the HFIAS records participants' perceptions of food vulnerability and responses to food insecurity, or lack of access to food (Coates et al., 2007). Farm diversity is a count variable measuring the number of food groups a household produces, where individual crops are classified in food groups following the FAO guidelines for dietary diversity (Kennedy et al., 2010). Studies have shown farm diversity is positively correlated with household dietary diversity, so we expect households that produce a larger variety of food to have a higher meal diversity score (Jones et al., 2014).

[2] US $1 is approximately 78 BDT

Cultural norms such as religion and gender inequities can dictate individuals' consumption of food items. For example, women in Bangladesh generally consume less protein than men, and traditional hierarchies influence the allocation of food items within the household. Thus, for each individual, we also include covariates for religion, sex, age, and relationship to the head of household. Religion is a dummy variable equal to 1 if the participant identifies as Muslim, the majority religion in Bangladesh, and 0 otherwise. The sex of the individual is a dummy variable equal to 1 if the individual is female and 0 if the participant is male. Age is a continuous variable. The relationship to the head of household is a categorical variable equal to 1 for the individual's position in the family, where the categories include household head, spouse of household head, and other. Household head is omitted from the analysis. Education is included as a set of dummy variables where 1 indicates the highest level of education that the individual has completed (none, primary, secondary, junior secondary, SSC pass, or postsecondary) and 0 otherwise, where no education is the omitted category. We expect more educated individuals to be familiar with the health benefits of consuming a variety of food items and more receptive to the nutrition messages. We also include covariates for baseline nutrition knowledge and hunger at the time of the meal. Nutrition knowledge is a continuous score [0,36] based on responses to a set of questions about dietary recommendations, nutrient content of familiar food items, diet-disease relationships, and child and maternal nutrition. The questions follow the validated methods of Parmenter and Wardle (1999). Hunger at the time of the meal is a Likert scale variable [1,5] ranging from "not hungry at all" to "extremely hungry." Observations about hunger were collected after the participant had finished his or her meal.

In addition to measuring the treatment effects on meal diversity, we also seek to understand how the BPP and nutrition education interventions impact individual consumption behavior for specific food items. Our experimental design provides a unique opportunity to investigate which types of food items and how much of each food item participants consume, given nutrition information, when income and food access constraints are removed. Thus, in addition to the empirical analysis on meal diversity, we also measure the impacts of the nutrition education and BPP interventions on the consumption of each of the ten food items using linear regressions. The general form of the food item consumption model is:

$$(2)\ y_{ijm} = \alpha_0 + \alpha_1 plate + \alpha_2 N + \alpha_3 NG + \alpha_4 plate * N + \alpha_5 plate * NG + X_i' \alpha_n + \varepsilon_i$$

where y_{ijm} is the amount of food item *j* consumed by individual *i* during meal *m*. The treatment variables and covariates remain the same as defined in equation (1). Thus, the estimated value of α_1 represents the effect of the BPP nudge on the consumption of food item *j* when the participant is nudged by the plate alone, α_2 is the impact of nutrition education, *N*, on the consumption of food item *j*, and α_3 is the effect of nutrition education with a gender component, *NG*, on the consumption of food item *j*. The combined effects of the BPP nudge with *N* and *NG* are measured through the estimated values of the interaction terms, α_4 and α_5, respectively.

The above methodology tests the hypothesis that exposure to the BPP will nudge participants in Bangladesh to increase the diversity of food items consumed during a meal. We hypothesize that the BPP will be most effective when combined with nutrition education. The study also tests the impact of adding a gender component to the training, which we expect will have a higher impact than nutrition education alone since basic dietary recommendations are reiterated during the discussion about intra-household allocation of food. In addition, we explore the impact of the BPP and nutrition education interventions on individual consumption of specific food items. We expect participants in the BPP treatment group will consume more nutritious food items and less rice than the participants who were not exposed to the plate.

Following our hypotheses on meal diversity, we also expect the impact on the consumption of nutritious food items to be largest when the plate is combined with nutrition or nutrition and gender education.

IV. Results

Table 3 presents the descriptive statistics of individual and household characteristics for all participants by district. Our sample includes 1,105 individuals in the first meal, 1,077 of whom returned for meal two, for a total of 2,182 meal observations collected. Thus, the attrition rate was approximately 2.5 percent. Observations for which data are missing due to incomplete responses in the baseline and post-meal surveys are excluded from the analysis. Hence, the final sample for the analysis includes 2,077 meal observations. The Mymensingh district is slightly overrepresented with 54 percent of participants residing in this district. Although we intended to include an equal number of men and women in the study, our sample is 70 percent female, primarily due to the higher representation of women in the Borguna district. This reflects the woman-centric nature of the Shushilan MaNaR project. When possible, we recruited male members of the Shushilan beneficiary households, but we were unable to achieve 50 percent stratification by gender. The mean household income is 11,001 BDT, or approximately USD $140, per month, and the mean poverty score of 47 implies that 33.5 percent of the sample lives on less than USD $1.25 per day (Schneider, 2013). Participants from the Borguna district are more likely to be in poverty, have a lower household income, and are more food insecure than participants in Mymensingh. Most of our participants, 36 percent, have no formal education. This is not surprising since we recruited participants through organizations who serve rural households. On average, the households in our sample produce 3.4 different food groups. To account for spiritual norms surrounding food consumption, we also asked participants to identify the religious affiliation of their household. The majority of households in Bangladesh identify as Muslim, which is reflected in our sample. The average nutrition knowledge score of 18.9, just over 50 percent, confirms that our sample had a low comprehension of nutrition recommendations prior to the field experiment.

Table 4 shows mean per meal consumption (kg) of each of the ten food items. As one would expect according to the traditional Bengali diet, rice is the most widely consumed food item. On average, participants consumed 0.38 kg of rice during the field experiment. This is consistent with the amount of rice one would expect participants to consume if the lunch buffet is the primary source of food for the day. The average daily per capita rice consumption in Bangladesh is 495.5 grams, or 0.495 kg (Ahmed et al., 2013). Since we informed participants at least one day prior that a meal would be served at the event, we expect the participants would consider the lunch buffet as their primary source of calories for the day. As noted in the methodology section, our model controls for the individual's level of hunger at the time of the meal. Table 3 shows the average hunger score was 3.7, or "very hungry". By design, this field experiment removes income and access constraints to nutritious food items such as meat and dairy, which may be too expensive for many of the participants to purchase for home consumption. It is not surprising then, that the mean consumption of protein sources, chicken, fish, yogurt, and lentils, are also high. The average meal diversity score, MDS, is 0.77, which indicates that participants consumed relatively diverse meals at the experiment. Participants consumed 7.8 different food items on average.

Prior to the analysis, we conduct a paired t-test to verify the absence of order effects. The paired t-test results, p-value equal to 0.37, confirm that the mean difference in MDS_{BPP} and $MDS_{Regular}$ is not statistically significantly different for participants in plate treatments C versus

B when exposure to the BPP occurs in the first meal versus the second meal, respectively. Thus, we determine no order effects exist, and we analyze the pooled meal observation data.

Table 5 presents the results of the regression on the meal diversity score. The linear regression includes the treatment indicator variables (corresponding to the treatments outlined in table 2) for the plate intervention, both education interventions, and the interactions between the plate and education treatments, controlling for the individual and household-level covariates described above. Standard errors are clustered at the community level. The coefficients on the education treatment variables, *N* and *NG,* as well as the interaction between the plate treatment and nutrition education, *plate*N*, are positive and statistically significant. These results suggest the individuals who engaged in the participatory workshop on nutrition consumed a more diverse meal than those who did not receive training. The individuals who participated in the nutrition training (N) consumed a slightly larger variety of food items than participants that did not receive the nutrition education and were not exposed to the plate; their MDS were 0.014 higher on average, a 1.8 percent increase on the mean. As expected, the impact of the combined nutrition and gender training is larger than nutrition education alone; the MDS for participants in the *NG* treatment was 0.017 higher on average than participants that did not participate in the gender component of the workshop and were not exposed to the plate. Some of the key nutrition messages, such as the importance of eating protein and leafy vegetables were reiterated during the gender training, so it is not surprising that repeating the messages led to a higher impact.

Confirming our hypothesis, the largest treatment effect comes from the combination of the “what goes on the plate” activity in the nutrition workshop and exposure to the BPP. Individuals who participated in the nutrition training and were also exposed to the BPP during the lunch buffet consumed a more diverse meal on average than the participants in the control group; on average their MDS were 0.018 higher, a 2.3 percent increase on the mean. However, the treatment interaction between exposure to the BPP and the combined trainings on nutrition and gender, *plate* NG*, is not statistically significant. This is likely due to the baseline level of nutrition knowledge in the *NG* treatment group. Although the interventions were randomly assigned, the group assigned to nutrition and gender training had a higher baseline understanding about nutrition according to the nutrition knowledge assessment scores. A Pearson's chi-squared test confirmed the statistically significant difference in nutrition knowledge between nutrition education treatment groups. Thus, the effect of prior nutrition knowledge of these participants captured in the nutrition knowledge assessment scores potentially damped the effect of the effect of *plate*NG*, rendering it insignificant.

While the effects of the education treatments fit our hypothesis, the BPP alone did not statistically significantly impact meal diversity. We suspect the plate alone is not effective because the key messages on the plate are written in Bengali (see panel a of figure 1). While we did not measure participant literacy directly, our sample is largely uneducated and hence likely illiterate. Therefore, it is reasonable to assume participants who have had no formal education or only completed primary school are unable to interpret the written messages on the BPP. The food images on the BPP were not sufficient to nudge individuals toward more diverse food choices. However, when the key messages are verbally communicated during the participatory training on nutrition, the plate nudges participants to consume a more diverse meal.

While the results of the paired t-tests imply that order of exposure to the BPP did not affect the plate's impact on MDS, we repeat the regression analysis with the inclusion of a dummy variable indicating the participant was exposed to the BPP at the second meal as a robustness check. Table 5 shows the indicator variable for order of exposure is not statistically significant, verifying the results of the paired tests. Thus, we confirm no order effects exist.

At the aggregate level, we are interested whether participants consume a more diverse set of foods given nutrition information. However, this study is also employs a unique approach to understand consumer behavior with respect to specific food items. The increase in meal diversity may be driven by a preference for certain nutrients or food items. Thus, in addition to the analysis on meal diversity, we also evaluate the treatment effects on the consumption of each individual food item. Table 6 presents the regression results on the consumption of each of the ten food items. Participants in the combined intervention of the BPP with nutrition education have a slightly lower average rice consumption, 0.31 kg less than individuals that did not receive nutrition training and were not exposed to the BPP; however the results show no other statistically significant effect on rice consumption. The consumption of lentils (dal) is 0.014 kg higher on average among individuals who were assigned to the nutrition education treatment and 0.017 kg higher on average for participants who received both nutrition and gender education compared to those who did not receive nutrition or gender training and were not exposed to the BBP. Additionally, participants who used the BPP and attended the nutrition training or nutrition and gender training consumed more lentils on average compared to the control group that was not exposed to the plate or receive any nutrition training, 0.023 kg and 0.016 kg, respectively. Furthermore, the average consumption of leafy green vegetables is slightly higher, 0.004 kg, for participants who received education treatments compared to those who did not receive nutrition or nutrition and gender education and were not exposed to the BPP; however there is no statistically significant effect on the consumption of leafy green vegetables when the trainings are combined with the BPP intervention.

The results of the regressions on specific food items suggest that the treatment effects on meal diversity may be driven by lentil consumption. This may be due to the pronounced image of lentils on the BPP. Alternatively, it is also possible that our participants were more familiar with lentils as a source of protein compared to other food items as lentils are a more affordable source of protein and hence might be consumed in the home more frequently than other protein sources.

V. Conclusions

Several development initiatives aim to promote nutrition among agricultural households in Bangladesh and the greater South Asia region. Food-based diagrams and food plate tools are especially popular tools to communicate nutrition information, and in certain cases, can be used to nudge individuals toward healthier food choices. However, initiatives for communicating any type of behavior change can be costly in developing countries. For the initiative to be successful, it is critical that the characteristics of the target population be taken into account in the design and implementation of behavior change strategies. Furthermore, evidence-based pilot testing and impact evaluation of the initiative should be implemented prior to scaling up the initiative.

In this study we conduct an experiment using meal observation data to measure the impacts of a melamine plate printed with Bengali food-based nutrition guidelines on food choice and meal diversity. In addition to the plate, our study measures the effect of participatory trainings on nutrition and gender norms surrounding nutrition. The results of this randomized controlled trial show that exposure to the printed BPP alone is not enough to encourage individuals to consume a more diverse diet. However, when the BPP is combined with participatory training on nutrition, individuals consume a more diverse meal. In Bangladesh, nutrition guidelines especially emphasize a reduction in rice consumption. Thus, we also use the meal observation data to test the effect of the plate and training interventions on rice consumption as well as the consumption of other food items. In general, we find the interventions are not successful at decreasing rice consumption except for the combined treatment of the BPP and the nutrition training, where rice consumption was lower on average compared to participants who did not receive the nutrition training and were not exposed to the BPP. We suspect the ineffectiveness of the BPP at nudging participants toward a diverse diet is due to low literacy levels among our target population. The key messages on the BPP are written in Bengali, thus the information might not be conveyed to illiterate participants. However, participatory training at the community level is an effective approach to communicating information where literacy is a constraint, as we see with the combined treatment effect. We encourage policy makers to consider the appropriateness of nutrition training tools for the education level and literacy of the target population. Further research is necessary to determine if the results would differ if participants had a higher rate of literacy.

This study employs a novel approach to evaluating nutrition-sensitive initiatives in agricultural development. Drawing upon research from the developed world, this randomized controlled trial uses meal observation data collection methods to investigate the use of behavioral economics strategies for improved nutrition in developing countries. The methods used in this study can be extended to other countries to evaluate similar strategies for nudging individuals to improve nutrition and dietary diversity.

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Figure 1. Bengali Portion Plate and regular plate used in the plate intervention

(a) (b)

USAID / FHI360 SHIKHA Food Plate (Bengali Portion Plate) Messages: “Half plate of rice and at least four other varieties of food”, “Eating a variety of food in appropriate amounts keeps mothers and children healthy”, “Eat a little more food during pregnancy” and “Wash both hands and soap with running water before preparing and eating food.”

Table 1: Experimental design: participant groups by combination of treatments

Plate Intervention	Nutrition Education Intervention		
Treatment (Meal 1, Meal 2)	No Nutrition Education	Nutrition Education	Nutrition and Gender Education
Treatment A (Regular, Regular)	Group 1	Group 2	Group 3
Treatment B (Regular, BPP)	Group 4	Group 5	Group 6
Treatment C (BPP, Regular)	Group 7	Group 8	Group 9

Table 2: Empirical analysis: treatment groups and indicator variables by intervention

Plate Intervention	**Nutrition Education Intervention**		
	No Nutrition Education	Nutrition Education	Nutrition and Gender Education
Regular plate	*(Control)*	*N*	*NG*
BPP	*Plate*	*Plate * N*	*Plate * NG*

Table 3. Descriptive statistics: covariates

	All		Borguna		Mymensingh	
Treatment variables	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Nutrition education	0.23	0.42	0.22	0.415	0.23	0.42
Nutrition and gender education	0.22	0.41	0.22	0.413	0.22	0.42
Plate intervention only	0.11	0.31	0.12	0.319	0.10	0.30
Plate + nutrition education	0.13	0.33	0.13	0.337	0.12	0.33
Plate + nutrition and gender education	0.12	0.32	0.12	0.322	0.11	0.32
Covariates	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**	**Mean**	**Std. Dev.**
Mymensingh district	0.54	0.50				
Household monthly income	11001.44	9466.80	6159.34	4885.36	15130.50	10425.22
Poverty score	48.59	16.00	38.27	11.04	57.42	14.20
Number of food groups produced	3.40	2.23	2.16	1.83	4.47	1.98
Household food insecurity access score	1.92	3.68	3.53	4.40	0.53	2.09
Religion (Muslim / non-Muslim)	0.95	0.21	0.91	0.28	0.99	0.11
Female	0.70	0.46	0.92	0.27	0.52	0.50
Age	38.03	12.50	38.54	11.67	37.59	13.17
Primary school (highest level)	0.33	0.47	0.44	0.50	0.24	0.43
Junior secondary school (highest level)	0.11	0.31	0.06	0.24	0.15	0.36
Secondary school (highest level)	0.06	0.24	0.02	0.14	0.10	0.30
SSC pass (highest level)	0.06	0.23	0.01	0.08	0.10	0.30
Postsecondary school (highest level)	0.07	0.25	0.00	0.06	0.12	0.33
Spouse of household head	0.51	0.50	0.66	0.47	0.39	0.49
Other relationship to household head	0.13	0.33	0.06	0.23	0.19	0.39
Hunger at time of meal event	3.71	1.17	3.13	1.16	4.21	0.93
Baseline nutrition knowledge score	18.86	5.10	17.38	5.23	20.12	4.63

Table 4. Descriptive statistics: dependent variables

Dependent variable	Mean (kg)	St. dev.
Rice	0.38	0.17
Chicken	0.08	0.04
Fish	0.08	0.04
Salad	0.05	0.05
Egg	0.06	0.02
Mixed vegetables	0.07	0.05
Leafy green vegetables	0.05	0.04
Lentils (dal)	0.09	0.09
Fruit (banana)	0.07	0.05
Yogurt	0.08	0.06
Meal diversity score	0.77	0.08
Number of food items	7.80	1.54

N = 2,077

Table 5. Meal diversity score regression results

VARIABLES	(1) MDS	(2) MDS
Nutrition education	0.014***	0.015***
	[0.005]	[0.005]
Nutrition and gender education	0.017***	0.017***
	[0.005]	[0.005]
Plate intervention	-0.005	-0.008
	[0.008]	[0.011]
Plate + nutrition education	0.018**	0.018**
	[0.008]	[0.008]
Plate + nutrition and gender education	0.009	0.009
	[0.007]	[0.007]
Mymensingh district	0.044***	0.043***
	[0.009]	[0.009]
Household monthly income	-0.000*	-0.000*
	[0.000]	[0.000]
Poverty score	0.000	0.000
	[0.000]	[0.000]
Number of food groups produced	0.000	0.000
	[0.001]	[0.001]
Household food insecurity access score	0.000	0.000
	[0.001]	[0.001]
Religion (Muslim / non-Muslim)	0.070***	0.071***
	[0.020]	[0.020]
Female	-0.004	-0.004
	[0.006]	[0.006]
Age	-0.000	-0.000
	[0.000]	[0.000]
Primary school (highest level)	0.004	0.004
	[0.004]	[0.004]
Junior secondary school (highest level)	-0.001	-0.001
	[0.006]	[0.006]
Secondary school (highest level)	0.012*	0.012*
	[0.007]	[0.007]
SSC pass (highest level)	0.013*	0.013*
	[0.007]	[0.007]
Postsecondary education	0.015*	0.015*
	[0.008]	[0.008]
Spouse of household head	-0.003	-0.003
	[0.006]	[0.006]
Other relationship to household head	-0.001	-0.001
	[0.007]	[0.006]

Hunger at time of meal event	0.003	0.003
	[0.002]	[0.002]
Baseline nutrition knowledge	0.001	0.001
	[0.000]	[0.000]
Order effect (plate in second meal)		0.005
		[0.013]
Constant	0.655***	0.654***
	[0.023]	[0.024]
R-squared	0.205	0.205

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1

Table 6. Regression results: consumption of each food item

VARIABLES	(1) Rice	(2) Chicken	(3) Fish	(4) Egg	(5) Lentil	(6) Salad	(7) Mixed veg	(8) Leafy veg	(9) Fruit	(10) Yogurt
Nutrition education	-0.015	0.004	-0.001	0.001	0.014**	0.004	0.004	0.004*	0.003	0.005
	[0.014]	[0.003]	[0.002]	[0.002]	[0.005]	[0.003]	[0.004]	[0.002]	[0.003]	[0.003]
Nutrition and gender education	-0.020	0.002	0.001	0.000	0.017***	0.002	0.002	0.005*	0.005*	0.005
	[0.013]	[0.003]	[0.003]	[0.002]	[0.004]	[0.003]	[0.004]	[0.003]	[0.003]	[0.004]
Plate intervention	-0.002	-0.003	-0.007	0.001	0.006	0.003	-0.006	-0.000	-0.001	-0.005
	[0.015]	[0.004]	[0.004]	[0.002]	[0.005]	[0.006]	[0.005]	[0.004]	[0.007]	[0.005]
Plate + nutrition education	-0.031*	-0.002	-0.001	0.001	0.023***	0.004	0.003	0.002	0.010	0.005
	[0.017]	[0.004]	[0.005]	[0.003]	[0.008]	[0.005]	[0.006]	[0.003]	[0.007]	[0.006]
Plate + nutrition and gender education	-0.015	-0.000	-0.006	-0.002	0.016**	0.000	-0.000	0.003	0.009	0.002
	[0.015]	[0.004]	[0.004]	[0.003]	[0.008]	[0.004]	[0.005]	[0.004]	[0.007]	[0.006]
Mymensingh district	-0.053**	0.008*	0.019***	-0.008***	0.049***	0.021***	-0.018***	-0.036***	0.044***	0.042***
	[0.021]	[0.005]	[0.003]	[0.002]	[0.007]	[0.007]	[0.006]	[0.004]	[0.007]	[0.007]
Household monthly income	0.000	-0.000	-0.000	-0.000	-0.000	-0.000	0.000	-0.000	0.000	-0.000
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Poverty score	-0.001*	-0.000	-0.000	0.000	0.000	-0.000	0.000**	0.000	-0.000	0.000
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Number of food groups produced	-0.004	0.000	0.000	-0.000	-0.000	0.000	-0.000	0.000	-0.001	-0.000
	[0.003]	[0.001]	[0.000]	[0.000]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]	[0.001]
Household food insecurity access score	0.002	0.001**	0.000	0.000	0.000	0.000	0.001*	-0.000	0.000	0.001
	[0.002]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.001]
Religion (Muslim / non-Muslim)	0.117***	0.019**	0.012***	0.021***	0.004	-0.004	0.018*	0.020***	-0.015**	-0.021**
	[0.033]	[0.008]	[0.004]	[0.006]	[0.009]	[0.016]	[0.010]	[0.006]	[0.006]	[0.009]
Female	-0.060***	-0.012***	-0.015***	-0.006***	-0.048***	-0.014***	-0.006	-0.003	0.009	-0.006
	[0.015]	[0.004]	[0.004]	[0.002]	[0.011]	[0.005]	[0.005]	[0.003]	[0.007]	[0.005]
Age	-0.000	-0.000*	-0.000	-0.000**	0.000	-0.000	-0.000	-0.000**	0.000*	0.000
	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Primary school (highest level)	0.002	0.001	-0.003	-0.001	0.005	-0.001	0.003	-0.002	0.001	0.002
	[0.010]	[0.002]	[0.002]	[0.001]	[0.004]	[0.003]	[0.003]	[0.002]	[0.002]	[0.003]

Junior secondary school (highest level)	-0.012	0.004	-0.004	-0.002	-0.010	-0.003	0.003	-0.002	-0.005	-0.006
	[0.015]	[0.003]	[0.003]	[0.001]	[0.010]	[0.004]	[0.004]	[0.003]	[0.005]	[0.004]
Secondary school (highest level)	0.001	0.002	0.004	0.001	-0.001	-0.001	0.014**	0.006	-0.003	0.002
	[0.024]	[0.005]	[0.003]	[0.002]	[0.009]	[0.005]	[0.006]	[0.005]	[0.006]	[0.006]
SSC pass (highest level)	-0.004	0.004	0.004	0.001	0.001	0.004	0.001	-0.000	-0.000	0.008
	[0.014]	[0.004]	[0.004]	[0.002]	[0.009]	[0.006]	[0.006]	[0.004]	[0.007]	[0.005]
Postsecondary education (highest level)	-0.055**	0.005	-0.007*	0.002	-0.008	0.015**	0.005	0.005	-0.003	0.003
	[0.025]	[0.005]	[0.004]	[0.002]	[0.015]	[0.007]	[0.006]	[0.005]	[0.007]	[0.007]
Spouse of household head	0.031**	0.000	0.003	-0.000	0.000	0.004	0.004	0.004	0.005	0.005
	[0.014]	[0.003]	[0.002]	[0.001]	[0.005]	[0.004]	[0.003]	[0.003]	[0.003]	[0.004]
Other relationship to household head	0.003	0.000	-0.001	-0.001	-0.010	-0.002	-0.002	0.000	-0.004	-0.002
	[0.017]	[0.004]	[0.003]	[0.002]	[0.007]	[0.004]	[0.005]	[0.003]	[0.005]	[0.005]
Hunger at time of meal event	0.000	0.003	0.004***	0.000	0.002	0.002	0.001	0.003**	0.001	0.004**
	[0.006]	[0.002]	[0.002]	[0.001]	[0.002]	[0.002]	[0.002]	[0.001]	[0.002]	[0.002]
Baseline nutrition knowledge	0.000	0.000	0.000	-0.000	-0.000	0.000	0.000*	0.000	0.000	0.001**
	[0.001]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
Constant	0.386***	0.051***	0.053***	0.050***	0.083***	0.040***	0.045**	0.047***	0.032**	0.044***
	[0.043]	[0.012]	[0.010]	[0.008]	[0.021]	[0.014]	[0.017]	[0.008]	[0.015]	[0.013]
R-squared	0.087	0.079	0.161	0.073	0.188	0.096	0.031	0.146	0.141	0.172

Robust standard errors in brackets
*** p<0.01, ** p<0.05, * p<0.1