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Statistical Analysis Plan:
iLiNS DYAD-G Hypothetical Willingness-to-Pay for LNS-P&L and Soybean Flour at Baseline

Contents

1) Overview and Study Objectives

In this paper we will present baseline estimates of hypothetical willingness-to-pay (WTP) for a small-quantity preventative lipid-based nutrient supplement (LNS) product formulated for consumption during pregnancy and the first six months of lactation (LNS-P&L, hereafter). Preventative LNS products, including LNS-P&L, are intended to be consumed daily for many months as a supplement to traditional foods (Dewey and Arimond 2012; Nutriset 2011). This is in contrast to ready-to-use therapeutic foods such as Plumpy'Nut©, which are primarily used in emergency settings and are administered in relatively large doses over a short period of time to treat children with severe acute malnutrition. While the international donor community has historically purchased and distributed therapeutic nutritional products for severely malnourished children for free via public channels, the differences in usage of preventative LNS products coupled with the potentially large and heterogeneous population of women and children who may benefits from them will make full subsidization of preventative LNS products much more expensive and less likely (Lybbert 2012). Thus, a hybrid distribution system that reaches target consumers through both public channels and retail markets may be recommended.

In this hybrid setting, in addition to the opportunity costs associated with procuring and consuming preventative LNS products, some households may also be required to pay for them. Our estimates of willingness-to-pay (WTP) for LNS-P&L[1] will shed light on household valuation of LNS-P&L and the factors that influence WTP. Moreover, our data on WTP for soybean flour will provide a benchmark from which we can evaluate WTP for LNS-P&L relative to a familiar, locally-available product. This collection of results will provide a starting point for characterizing demand for LNS-P&L, which in turn may guide policy decisions regarding the price LNS-P&L consumers might be expected to pay as well as help establish targeting mechanisms to distribute LNS-P&L.

2) Description of the Study

A more detailed description of the iLiNS study, including the study population, inclusions and exclusion criteria, etc. is available in the main statistical analysis plan (iLiNS-DYAD-G Statistical Analysis Plan Version 2, 2013-06-15). In short, screening, recruitment and enrollment of pregnant women into the randomized controlled trial were done on a rolling basis over a two-year period from December 2009 to December 2011. During this period, women attending select prenatal clinics in the Manya Krobo and Yilo Krobo districts in the Eastern Region of Ghana were screened for potential participate in the trial. Eligible and willing women were then recruited to participate in the study and randomized into one of the trial's three equally-sized arms in which women received: (1) daily iron-folic acid tablets throughout pregnancy, the current standard of prenatal care in Ghana, and a placebo (low-dose calcium tablet) during the

[1] The randomized trial is evaluating the efficacy of LNS for both maternal and early childhood consumption. Data on WTP for LNS for child consumption have also been collected and will be analyzed in a separate study.

first six months of lactation, (2) daily multiple micronutrient tablets during pregnancy and the first six months of lactation, or (3) LNS-P&L during pregnancy and the first six months of lactation.[2]

Using contingent valuation methods, we elicited hypothetical WTP for a day's supply of LNS-P&L from a random subsample of households participating in the iLiNS DYAD-G randomized controlled nutrition trial in Ghana. As a comparator, we also elicited hypothetical WTP for a day's supply of soybean flour, a familiar, locally-available product commonly sold by nurses to women attending prenatal clinics in the iLiNS study area. For both LNS-P&L and soybean flour, after eliciting WTP for a day's supply of the product, we used a set of follow-up questions[3] to assess hypothetical WTP in the long-term (i.e., throughout pregnancy).

3) Hypotheses to be Tested

Let X be the vector of explanatory variables, defined in section 4 below. For each explanatory variable, x, the following null hypothesis (H_0) tests will be carried out to test for an association between the explanatory variable and baseline hWTP. The explanatory variables were chosen based on economic theory, previous empirical research, and policy relevance.

H_0 1: There is no systematic association between x and baseline short-term hypothetical WTP for LNS-P&L.

H_0 2: There is no systematic association between x and baseline short-term hypothetical WTP for soybean flour.

H_0 3: There is no systematic association between x and baseline long-term hypothetical WTP for LNS-P&L.

H_0 4: There is no systematic association between x and baseline long-term hypothetical WTP for soybean flour.

H_0 5: There is no systematic association between x and the difference in baseline short-term hypothetical WTP for LNS-P&L and soybean flour.

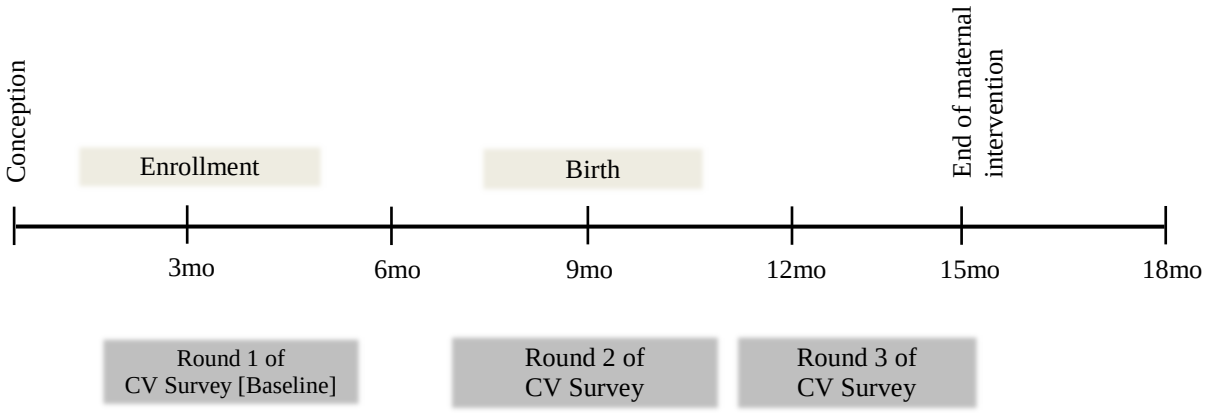
H_0 6: There is no systematic association between x and the difference in baseline long-term hypothetical WTP for LNS-P&L and soybean flour.

[2] Children born to these women also received an LNS product specifically formulated for their babies from 6-18 months of age. The babies of the women randomized into the iron-folic acid and multiple micronutrient tablet groups did not receive any supplementation.

[3] These follow-up questions began with the following: "You have told me that you would be willing to pay [maximum WTP] today for one sachet of nkate pa. Would you be willing to pay [maximum WTP] per day for 1 sachet of nkate pa throughout your pregnancy?" If the answer was 'no', then the following was asked: "What price do you think you could pay every day for 1 sachet of nkate pa throughout your pregnancy?"

4) Description of Variables

The following sections describe the dependent and explanatory variables that will be used to model WTP. Note that the baseline contingent valuation survey was to be administered within a few weeks of enrollment. However, due to logistical reasons and difficulty locating some respondents (traveling, working away from home, etc.), contingent valuation surveys were, at times, administered many weeks from the planned date of enumeration. As such, there is quite a bit of variation in the number of weeks that passed between enrollment and administration of the survey at each round, which also created within-round variation in the amount of time a particular respondent had to accumulate experience with LNS-P&L. The timeline in the figure below, where time is measured in months from conception of the baby, shows the relationship between maternal enrollment into the randomized trial and the birth of her baby relative to the actual timing of each round[4] of the contingent valuation survey. The grey boxes indicate the approximate range of time when enrollment, birth, and contingent valuation surveys were administered.



Timeline: Maternal Intervention and Contingent Valuation (CV) Survey

4.1 Dependent Variables

- WTP for a day's supply of LNS-P&L at baseline in 4th quarter 2011 US dollars.
- WTP for a day's supply of soybean flour at baseline in 4th quarter 2011 US dollars.
- Difference in WTP for a day's supply of LNS-P&L and soybean flour at baseline in 4th quarter 2011 US dollars.
- Long-term (i.e. throughout pregnancy) WTP for a day's supply of LNS-P&L at baseline in 4th quarter 2011 US dollars.

[4] The focus of this manuscript will be baseline hWTP only.

- Long-term (i.e. throughout pregnancy) WTP for a day's supply of soybean flour at baseline in 4th quarter 2011 US dollars.

- Difference in Long-term (i.e. throughout pregnancy) WTP for a day's supply of LNS-P&L and soybean flour at baseline in 4th quarter 2011 US dollars.

Note: The distributions of WTP for LNS-P&L and soybean flour are right-skewed. To account for this in our models, we may transform WTP to ln(WTP).[5]

4.2 Explanatory Variables

Maternal consumption of LNS-P&L may have private benefits that accrue to the mother and her child at different points along the lifecycle. The immediate- and short-term benefits potentially include improved maternal micronutrient stores leading to improvements in maternal mood during pregnancy and lactation (Beard et al. 2005; Leung and Kaplan 2009) and reduced maternal (Hardee et al. 2011; Lartey 2008) and child (Martorell 1999; Allen and Gillespie 2001) morbidity, which may decrease household expenditures on health care and ease the household's time and, perhaps, budget constraints by freeing up maternal time spent ill or caring for a sick child. In the long-term, the household may benefit from improvements in the child's physical capacity, cognitive ability, and accumulation of human capital, leading to productivity gains in adulthood (Alderman 2010) and thus increasing the household's incentive to invest in maternal and early childhood health.

There may also be costs associated with maternal consumption of LNS-P&L, such as the time spent procuring and consuming LNS-P&L or any unpleasant physical side-effects associated with its consumption. Given household preferences and constraints, a household's expected stream of benefits (which may be shaped by characteristics such as level of education, demographic composition of the household, discount rate, and maternal health) coupled with costs associated with consuming LNS-P&L will influence the private value (or willingness-to-pay) for LNS-P&L. The expected relationship[6] between WTP and the following respondent, household, maternal characteristics will be tested using Ordinary Least Squares (OLS) models as described in Section 5 below.[7]

[5] Because the natural log of zero is undefined, we will set all zero WTP values to a value slightly smaller than the minimum non-zero value of ln(WTP).

[6] In some cases, the relationship between WTP and a covariate may be non-linear. In particular, respondent age, respondent income, household food security, and household expenditures may have an inverted u-shaped relationship with WTP, where WTP is lower at the tails of the covariate distribution. To account for this this potential non-linearity, we may also include squared terms.

[7] Note that some of the variables included in this list (and any variant of them, including squared terms and interactions) may be too highly correlated to include both in the model. We will test all independent variables for correlation and omit those deemed to be too highly correlated.

Respondent Baseline Characteristics

- iLiNS Woman: Indicator variable that = 1 if the respondent is the iLiNS woman and = 0 if respondent is the head of his/her household.[8]

- Age: Respondent's age in years.

- Education: Number of completed years of formal education by the respondent.

- Income: Self-reported measure of the amount typically earned per day by the respondent in his/her primary work in 4th quarter 2011 US dollars.

- Discount rate: Relative measure of respondent's discount rate determined by playing a game at baseline in which a respondent was shown two equal-sized tins of rice and was then asked to measure out the quantity (from 0-10) of rice into a third tin that would make him/her indifferent between receiving the first tin of rice alone in a week and the second tin plus the additional amount measured into the third tin in one month.[9]

Household Baseline Characteristic

- Children Under Five: The number of children under five years of age who are household members[10] at baseline.

- Percent Under Five: The percentage of household members who are under five years of age at baseline, defined as (children under five/household size)*100.

- HFIA Score: The Household Food Insecurity Access (HFIA) Score is a continuous measure of the degree of food insecurity in the household. For each of nine questions, the survey respondent, who is the person primarily responsible for food preparation and meals in the household, indicates whether anyone in her household experienced the food insecurity condition in the previous four weeks. If yes, the respondent indicates how frequently the specific condition was experienced, where 'rarely' = 1-2 times in the past four weeks, 'sometimes' = 3-10 times in the past four weeks, and 'often' = more

[8] The respondent to the contingent valuation survey was determined randomly (by the tossing a coin) to be either the iLiNS woman or the head of household. In cases where the iLiNS woman is also the head of household, this variable will be coded as =1 (iLiNS woman).

[9] To determine whether the respondent received rice in a week or a month, s/he rolled a 10-sided die. If the number rolled was smaller than the amount of rice measured, the first tin of rice alone was delivered to the respondent in a week, and if the number rolled was equal to or greater than the amount of rice measured, the second tin of rice plus the amount measured into the third tin was delivered to the respondent in a month. The quantity of additional rice measured into the third tin by the respondent serves as his/her individual discount rate relative to the rest of the sample.

[10] Household members are defined as people who have been regularly sleeping in the same dwelling and sharing food from the same cooking pots for at least the last three months.

than 10 times in the past four weeks. Each household receives a score from 0-27 based on a simple sum of the frequency of occurrence of each food insecurity condition, where 'never' = 0 points, 'rarely' = 1 point, 'sometimes' = 2 points, and 'often' = 3 points. The higher the score, the higher the degree of household food insecurity experienced in the previous four weeks.

- Household Asset Index: A proxy measure of household socioeconomic status based on baseline ownership of a set of assets (radio, television, refrigerator, cell phone, and stove), lighting source, drinking water supply in the dry season, sanitation facilities, and flooring materials. Household ownership of this set of assets is combined into an index (with a mean of zero and standard deviation of one) using principal components analysis. Higher asset index scores indicate relatively 'better-off' households.

- Household Per Capita Expenditures: Total daily per capita (PC) expenditures, composed of non-food expenditures plus food expenditures (which includes the value of purchased and home-produced foods) in 4th quarter 2011 US dollars.

- Percent Food Expenditures: The percentage of total daily per capita expenditures that go toward food, defined as (PC daily food expenditures/PC total daily expenditures)*100.

- Risk Behavior: An indicator of the iLiNS woman's willingness to take on risk as measured by the amount she risked in a game of chance. In the game, the iLiNS woman was given GH¢ 2, and she indicated how much of that she would like to bet. After she stated her bet, she rolled a 6-sided die. If she rolled a one, two, or three, she was given double the amount of money she bet. If she rolled a four, five, or six, she lost half of her bet.

Maternal Baseline Characteristics

- Maternal height: Mother's height in meters measured at enrollment.[11]

- Adjusted maternal BMI: Mother's body mass index at enrollment adjusted for gestational age.[12]

- Primiparity: Dummy variable = 1 if iLiNS baby is mother's first child.

[11] The perceived importance of maternal height may be relative to the height of other women in the iLiNS study catchment area. As such, we may also normalize maternal height by the average height of women in the iLiNS DYAD-G trial.

[12] Similar to height, the perceived importance of maternal BMI may be relative to the BMI of other women in the iLiNS study catchment area. As such, we may also normalize maternal BMI by the average BMI of women in the iLiNS DYAD-G trial.

- LNS: Dummy variable = 1 if iLiNS woman randomized to receive LNS-P&L and = 0 if iLiNS woman randomized to receive IFA or MMN tablets.[13]

- Gestational age at enrollment: Number of weeks pregnant at enrollment.

- Weeks Enrolled: Number of weeks from enrollment to contingent valuation survey administration.

Other Covariates/Controls

- Month: Dummy variables indicating the month the baseline contingent valuation survey was administered.

- Year: Dummy variables indicating the year the baseline contingent valuation survey was administered.

- Enumerator: Set of enumerator control variables.

- Version of Questionnaire: Set of control variables for version of contingent valuation survey to control for starting 'bid' and first product (LNS-P&L or soybean flour).

Possible Interaction Terms

- iLiNS Woman * LNS

- iLiNS Woman * Weeks Enrolled

5) Statistical Methods

5.1 Data Cleaning

Cleaning of the SES data follows the same procedure outlined in the main analysis plan (iLiNS-DYAD-G Statistical Analysis Plan Version 2, 2013-06-15), with Katie Adams generating the queries and Emmanuel Ayifah resolving the queries.

5.2 Outliers

Identification and treatment of outliers in the SES data and maternal nutrition variables will follow the treatment described in the main statistical analysis plan (iLiNS-DYAD-G Statistical Analysis Plan Version 2, 2013-06-15).

[13] We may also estimate the models using an LNS-P&L treatment group dummy variable and a MMN treatment group dummy variable (IFA will be the omitted group) to assess whether there is any statistically significant difference in WTP, all else equal, across the three treatment arms.

5.3 Software

All statistical analyses will be performed with Stata 13 statistical package.

5.4 Analysis

5.4.1 Summary Baseline Characteristics

Summary statistics, including mean (count for dichotomous variables), standard deviation (percentage for dichotomous variables), minimum, and maximum for all explanatory variables will be presented in Table 1. As a check for the success of the randomization, we will report any differences in mean explanatory variables across treatment groups.

5.4.2 Summary of Short- and Long-Term WTP

Summary statistics, including mean, standard deviation, minimum, and maximum for short-term (i.e., a day's supply) WTP for LNS-P&L, soybean flour, and the difference in short-term WTP between the two products will be presented in Table 2. Table 3 will present summary statistics for short-term WTP across treatment groups (i.e., LNS vs combined IFA/MMN) and respondents (i.e., iLiNS woman vs head of household).

Tables 4 and 5 will present the same summary statistics but for long-term (i.e., throughout pregnancy) WTP for LNS-P&L, soybean flour, and the difference in long-term WTP between the two products.

5.4.3 Factors Associated with WTP

Regression results will be presented in Table 6 (short-term WTP) and Table 7 (long-term WTP). We will use ordinary least squares (OLS)[14] to estimate the relationship between baseline[15] WTP for LNS-P&L and a set of characteristics that, based on theory and previous empirical work, we expect to be associated with WTP.

For $i = 1, 2, \dots, N$ contingent valuation survey respondents and $m = 1, 2, \dots M$ iLiNS mothers,[16] we will estimate $WTP_i = \alpha + X_i'\beta_x + H_i'\beta_h + N_m'\beta_n + C_i'\beta_c + u_i$, where WTP_i is respondent $i's$ stated maximum WTP for a day's supply of LNS-P&L, X_i is a vector of respondent baseline socioeconomic characteristics, H_i is a vector of respondent $i's$ household baseline

[14] If WTP is censored at zero - that is, WTP is actually negative (and unobserved) for some respondents who would require payment to take LNS-P&L/soybean flour - OLS may lead to inconsistent estimates (Cameron and Trivedi 2005). A tobit model can be used to account for censoring but is not without tradeoffs. The tobit model relies on normally distributed and homoscedastic errors for consistency, and since we observe only a small proportion of zeros in our data (5-8% of WTP for LNS-P&L and 10-15% for soybean flour), we opt for OLS over a tobit specification.

[15] Data on WTP was also collected at approximately 35 weeks of gestation and three months after the birth of the iLiNS baby. These data will be analyzed in the separate study.

[16] In cases where the iLiNS mother was the respondent to the contingent valuation survey, the respondent, denoted i, is also the iLiNS woman, denoted m.

socioeconomic characteristics, N_m is a vector of maternal baseline characteristics including indicators of maternal nutritional status, C_i is a vector of other control variables, and u_i is the error term. We will estimate a parallel model for baseline WTP for soybean flour.

We will also use OLS to estimate the factors associated with the difference in WTP for LNS-P&L and soybean flour at baseline, defined as $WTP(LNS-P\&L)_i - WTP(Soybean\ Flour)_i$. This will be modeled as $WTP(LNS-P\&L)_i - WTP(Soybean\ Flour)_i = \alpha + X_i'\beta_x + H_i'\beta_h + N_m'\beta_n + C_i'\beta_c + u_i$.

6) Design of Tables

Table 1. Baseline Respondent, Household, and Maternal Characteristics

	Variable	Definition	Mean/ Count	Std Dev/ Percent	Min	Max
Respondent	iLiNS Woman	= 1 if respondent is iLiNS woman (= 0 if head of household)	xxx	xx.xx		
	Age	Age in years	xx.xx	xx.xx	xx	xx
	Education	Years of education				
	Discount Rate	Relative measure of time discounting				
	Daily Income	Income in 4th Quarter 2011 USD				
Household	Children U5	Number of household members who are children under five years				
	Percent Children U5	Percent of children under 5 in hh				
	HFIA Score	Household Food Insecurity Access Score				
	Asset Index	Proxy for socioeconomic status				
	Per Capita Total Expenditures	Per capita daily total expenditures (4th Quarter 2011 USD)				
	Percent Food Expenditures	Percent of total household expenditures made on food				
Maternal	Risk Behavior†	Relative measure of willingness to take a risk				
	First Child	=1 if the iLiNS woman has no other children				
	Height	Height in meters				
	Adjusted BMI	Body mass index adjusted for gestational age				
	Gestational Age at Enroll	Gestational age in weeks at enrollment				
	Weeks Enrolled	Number of weeks from enrollment to survey administration				

N = xxx

† For women who chose not to play the risk game, the risk measure was predicted using Heckman's two step procedure.

Significance codes: *** (p < .01), ** (p < .05), * (p < .1) indicate difference in means between LNS-P&L and the IFA/MMM treatment groups.

Table 2. Average WTP for a Day's Supply of LNS-P&L and Soybean Flour at Baseline

Product	N	Mean† (Std Error)	Std Dev	Min	Max*	Zero WTP/ Difference
LNS-P&L	xxx	x.xx (x.xx)	x.xx	x.xx	x.xx	xx (x.x%)
Soybean Flour						
LNS-P&L – Soybean Flour						

†In 4th Quarter 2011 US Dollars
*Observations > 4 SD above the mean were omitted as outliers.
Significance codes: *** (p < .01), ** (p < .05), * (p < .1) indicate different mean WTP across products.

Table 3. Average WTP for a Day's Supply of LNS-P&L and Soybean Flour at Baseline by Treatment Group and Respondent

Product		N	Mean	Std Error
LNS-P&L	Overall	xxx	x.xx	x.xx
	LNS-P&L			
	Non-LNS-P&L			
	iLiNS Woman			
	Head of Household			
Soybean Flour	Overall			
	LNS-P&L			
	Non-LNS-P&L			
	iLiNS Woman			
	Head of Household			
LNS-P&L – Soybean Flour	Overall			
	LNS-P&L			
	Non-LNS-P&L			
	iLiNS Woman			
	Head of Household			

†In 4th Quarter 2011 US Dollars.
For treatment groups: significant codes *** (p < .01), ** (p < .05), * (p < .1) indicate mean WTP for LNS group different than IFA/MMN group for same product.
For respondents: significant codes *** (p < .01), ** (p < .05), * (p < .1) indicate mean WTP for iLiNS women different than heads of household for same product.

Table 4. Average Long-Term WTP for LNS-P&L and Soybean Flour at Baseline

Product	N	Mean† (Std Error)	Std Dev	Min	Max*	Zero WTP/ Difference
LNS-P&L	xxx	x.xx (x.xx)	x.xx	x.xx	x.xx	xx (x.x%)
Soybean Flour						
LNS-P&L – Soybean Flour						

†In 4th Quarter 2011 US Dollars
*Observations > 4 SD above the mean were omitted as outliers.
Significance codes: *** (p < .01), ** (p < .05), * (p < .1) indicate different mean WTP across products.

Table 5. Average Long-Term WTP for LNS-P&L and Soybean Flour at Baseline by Treatment Group and Respondent

Product		N	Mean	Std Error
LNS-P&L	Overall	xxx	x.xx	x.xx
	LNS-P&L			
	Non-LNS-P&L			
	iLiNS Woman			
	Head of Household			
Soybean Flour	Overall			
	LNS-P&L			
	Non-LNS-P&L			
	iLiNS Woman			
	Head of Household			
LNS-P&L – Soybean Flour	Overall			
	LNS-P&L			
	Non-LNS-P&L			
	iLiNS Woman			
	Head of Household			

†In 4th Quarter 2011 US Dollars.
For treatment groups: significant codes *** (p < .01), ** (p < .05), * (p < .1) indicate mean WTP for LNS group different than IFA/MMN group for same product.
For respondents: significant codes *** (p < .01), ** (p < .05), * (p < .1) indicate mean WTP for iLiNS women different than heads of household for same product.

Table 6. Regression Results: Baseline WTP for a Day's Supply (4th Quarter 2011 USD)

		Coefficient (Robust Standard Error)		
	Variable	LNS-P&L	Soybean Flour	Difference
Respondent	iLiNS Woman (0/1)	x.xxx (x.xxx)	x.xxx (x.xxx)	x.xxx (x.xxx)
	Age (yrs)			
	Education (yrs)			
	Relative Discount Rate			
	Daily Income (USD)			
Household	Children U5			
	Percent Children U5			
	HFIA Score			
	Asset Index			
	Per Capita Total Expenditures (USD)			
	Percent Food Expenditures			
Maternal	Risk Behavior			
	First Child (0/1)			
	Height (meters)			
	Adjusted BMI			
	Gestational Age at Enrollment (weeks)			
	Weeks Enrolled			
	LNS-P&L (0/1)			
	LNS-P&L * iLiNS Woman			
	Weeks Enrolled * iLiNS Woman			
	Constant			
	N	xxx	xxx	xxx
	R^2	x.xxx	x.xxx	x.xxx

Significance codes: *** (p < .01), ** (p < .05), * (p < .1)

Note: Controls for month and year of enumeration, enumerator, and questionnaire version were also included in the model (unreported).

Table 7. Regression Results: Long-Term Baseline WTP (4th Quarter 2011 USD)

		Coefficient (Robust Standard Error)		
	Variable	LNS-P&L	Soybean Flour	Difference
Respondent	iLiNS Woman (0/1)	x.xxx (x.xxx)	x.xxx (x.xxx)	x.xxx (x.xxx)
	Age (yrs)			
	Education (yrs)			
	Relative Discount Rate			
	Daily Income (USD)			
Household	Children U5			
	Percent Children U5			
	HFIA Score			
	Asset Index			
	Per Capita Total Expenditures (USD)			
	Percent Food Expenditures			
Maternal	Risk Behavior			
	First Child (0/1)			
	Height (meters)			
	Adjusted BMI			
	Gestational Age at Enrollment (weeks)			
	Weeks Enrolled			
	LNS-P&L (0/1)			
	LNS-P&L * iLiNS Woman			
	Weeks Enrolled * iLiNS Woman			
	Constant			
	N	xxx	xxx	xxx
	R^2	x.xxx	x.xxx	x.xxx

Significance codes: *** (p < .01), ** (p < .05), * (p < .1)
Note: Controls for month and year of enumeration, enumerator, and questionnaire version were also included in the model (unreported).

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