AGRICULTURAL ECONOMICS

Agricultural Economics 47 (2016) 1–15

Using an economic experiment to estimate willingness-to-pay for a new maternal nutrient supplement in Ghana

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Received 19 February 2015; received in revised form 11 January 2016; accepted 22 April 2016

Abstract

Scaling up access to supplements designed to prevent undernutrition, such as new small-quantity lipid-based nutrient supplements (SQ-LNS), may require distribution via both public channels and retail markets. The viability of SQ-LNS retail markets will hinge on household-level demand. We use an economic experiment to characterize initial willingness-to-pay (WTP) for a maternal SQ-LNS product in Ghana. WTP is positive for most participants, though below the estimated cost of production for many. WTP varies depending on income, assets, and parity status. These findings have implications for the design of public health policy and hybrid public–private delivery mechanisms.

JEL classifications: C93, D12, O12, I15

Keywords: Undernutrition; Lipid-based nutrient supplements; Willingness-to-pay; Field experiment; Ghana

1. Introduction

Maternal and early childhood undernutrition are responsible for millions of childhood deaths and episodes of disease every year in developing countries (Black et al., 2013). These nutritional deficiencies can have irreversible long-term effects: children who suffer from undernutrition during critical early stages of life can then have permanent developmental impairments that stifle their cognitive functioning and physical growth, ultimately leading to deficits in schooling and losses in adult productivity (Alderman and Behrman, 2006; Alderman et al., 2007; Hoddinott et al., 2008, 2013b; Martorell et al., 2010; Victora et al., 2008). In this context, improving maternal and early childhood nutrition among vulnerable populations can reduce infant mortality, dramatically improve health outcomes, and generate productivity gains and economic benefits in the long-term (Alderman, 2010; Hoddinott et al., 2013a). Such nutritional improvements, however, can be difficult to achieve in practice since they hinge on behavioral changes within households. While public health investments can help, nutritional outcomes among poor households are shaped critically by private consumption decisions.

The demonstrated success of ready-to-use therapeutic foods (RUTF) in the treatment of severely malnourished children in the developing world (Briend and Collins, 2010) has spurred the development of similar, ready-to-use products but with a much different focus: the *prevention* of maternal and early childhood undernutrition (Dewey and Arimond, 2012). In contrast to energy-dense RUTF which are typically administered to children in large doses over six to eight weeks for rehabilitative purposes, these preventative products, known as small-quantity lipid-based nutrient supplements (SQ-LNS), are intended to be consumed daily over many months and are designed to provide essential micronutrients and fatty acids as a supplement to breastfeeding and traditional foods (Arimond et al., 2015). And while RUTF have historically been purchased by international aid organizations (e.g., UNICEF, World Food Programme, Doctors Without Borders) and distributed free of charge through public channels, the intended duration of consumption of SQ-LNS and the size and heterogeneity of the population of potential beneficiaries, among other factors, mean that ensuring a constant supply of SQ-LNS to all vulnerable populations (which are much larger than those treated with RUTF) will be logistically involved and resource-intensive. As a result, full

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Data Appendix Available Online

A data appendix to replicate main results is available in the online version of this article.

DOI: 10.1111/agec.12257

subsidization of SQ-LNS will likely be outside the programmatic scope and financial capacity of national governments and of the international aid and donor communities, and delivery of SQ-LNS via hybrid distribution systems that reach target consumers through both public channels and retail outlets may emerge (Lybbert, 2011). Within a hybrid public-private delivery context, policy makers and donor agencies will face unique challenges in ensuring reliable, sustainable access to SQ-LNS and in stimulating demand for the supplements.

Navigating these novel delivery dilemmas will demand a rich empirical basis with which to formulate delivery decisions. At their core, the policy challenges associated with delivering SQ-LNS products to nutritionally vulnerable and, often, resource-poor households begin with household-level demand, how household characteristics—demographics, education, socioeconomic status, food insecurity, etc.—shape demand, and also how these characteristics might be utilized to design and manage cost-effective non-price (e.g., educational campaigns) and price-based (e.g., subsidies) product distribution strategies. In the end, the costs associated with producing/procuring, shipping and distributing SQ-LNS will have to be paid, but which stakeholder groups are called upon to shoulder which proportion of those costs remains to be determined. This paper focuses on potential consumers of SQ-LNS in rural Ghana and addresses the issue of how much of that cost burden these consumers may be willing to pay. We begin by building an understanding of households' initial valuation of SQ-LNS (i.e., for a single week's supply) and the factors that influence their valuations. In another setting, preliminary results from a modified Becker-Degroot-Marschak (BDM) experiment and a year-long market trial that sold an SQ-LNS product through retail outlets in rural Burkina Faso show that (a) bids on a week's supply of SQ-LNS generated via the BDM procedure are roughly indicative of what we might expect consumers to be willing-to-pay for an initial week's supply of SQ-LNS in a retail setting, and (b) initial demand for SQ-LNS is very price-sensitive, and even more so for repeat purchases (Lybbert et al., 2016). If these relationships hold in Ghana, then our results provide an estimate of the extent to which caregivers may be willing to pay for SQ-LNS in the marketplace, and of the residual costs that will have to be covered by other stakeholders, regardless of the distribution platform selected.

We conducted an economic experiment using the BDM procedure with pregnant and breastfeeding women in Ghana to elicit willingness-to-pay (WTP) for one specific SQ-LNS product, LNS-P&L, which is formulated for maternal consumption during pregnancy and throughout the first six months postpartum. Our results provide insight into initial demand for LNS-P&L as well as factors that may impede the initial uptake of this supplementary nutritional product. The analysis also highlights individual and household characteristics that shape demand for LNS-P&L and suggests policy and delivery implications.

We find that WTP for LNS-P&L is positive for almost all participants, but for a substantial portion of participants, even this initial WTP is below preliminary production cost estimates. WTP varies across participant and household characteristics, including level of education, being pregnant with or breastfeeding one's first child, household income, and access to credit. Quantile regression results show that, in some cases, the relationship between these characteristics and WTP varies in terms of magnitude and statistical significance across the distribution of WTP. Finally, we find that exposure to information about the long-term benefits of preventing maternal and early childhood undernutrition does not affect initial WTP for LNS-P&L. These findings have implications for the design of public health policy and hybrid public-private delivery mechanisms that may be required for vulnerable households to access SQ-LNS products.

2. Background: undernutrition and demand for health products

The first 1,000 days in a child's life, from conception through the second birthday, have been identified as *the* critical window for preventing undernutrition (Leroy et al., 2014; Victora et al., 2010), as the effects of undernutrition during this time, which can include growth faltering (i.e., deficits in growth relative to reference values), delayed motor, cognitive, and behavioral development, and increased morbidity and mortality, may be largely irreversible (Dewey and Adu-Afarwuah, 2008; Martorell, 1999; Victora et al., 2008). Children generally do not make a full recovery from the growth and developmental deficits imposed by undernutrition experienced before age two, ultimately leading to lower attained schooling, shorter adult stature, lower income, and decreased offspring birthweight, all of which impose considerable long-term private and social costs (Alderman and Behrman, 2006; Alderman et al., 2007; Belli et al., 2005; Victora et al., 2008).

Motivated by these critical first 1,000 days, the International Lipid-Based Nutrient Supplement (iLiNS) Project conducted a randomized controlled nutrition trial in Ghana to test the efficacy of SQ-LNS, including LNS-P&L.[1] Although the use of products such as micronutrient powders to enhance the nutritional content of maternal diets in developing countries is not new, LNS-P&L is a novel product designed to supplement the everyday diet of women during pregnancy and the first six months postpartum. LNS-P&L contains vegetable oil, peanut, dried skimmed milk, sugar, and a vitamin-mineral mix (Adu-Afarwuah et al., 2015).[2] And, because the micronutrients in LNS-P&L are embedded in a food base, not only do the supplements provide some additional macronutrients (fats, protein, and carbohydrates), some of the micronutrients may be more readily absorbed by the body than those delivered in capsule or powder form (Chaparro and Dewey, 2010).

[1] The International Lipid-Based Nutrient Supplement Project (iLiNS project) is evaluating the efficacy of SQ-LNS products in randomized controlled trials in Ghana, Malawi, and Burkina Faso.

[2] The nutrient content of a 20-gram daily serving of LNS-P&L is shown in Table A1 in Online Appendix A.

A randomized controlled trial in the Eastern Region of Ghana showed that providing women with LNS-P&L during pregnancy increased average birth weight by 85 grams (2.9%) relative to giving women iron-folic acid tablets during pregnancy (Adu-Afarwuah et al., 2015).[3] There was also statistically significant heterogeneity in the effect of SQ-LNS on birth outcomes by parity. Providing first-time mothers with SQ-LNS during pregnancy, compared to providing first-time mothers with either iron-folic acid tablets or multiple micronutrient tablets, improved birth weight, length and head circumference and decreased the incidence of low birth weight (birth weight <2500 grams), whereas there was no effect in multiparous mothers. LNS-P&L may, therefore, become an attractive option for incorporation into targeted maternal and early childhood nutrition strategies aimed at improving birth outcomes. Given that the delivery of SQ-LNS will not be fully subsidized through public distribution, however, many households may face out-of-pocket costs to access them – even if at subsidized prices. The literature on the demand for preventative health and nutritional products in developing countries suggests that households generally underinvest in preventative products relative to their potential private returns (Dupas (2011) provides an overview). There are two primary explanations for this common finding: (1) a lack of information about health risks and the potential returns to prevention and (2) financial impediments to adoption including credit constraints and barriers to savings (Dupas, 2011; Meredith et al., 2013).

Experimental valuation methods have been used in a number of studies in developing countries to evaluate the effect of information on the returns to investing in preventative health and nutritional products and technologies, with mixed results. Information on the health benefits of biofortified maize in Ghana (De Groote et al., 2010) and Zambia (Meenakshi et al., 2012) and nutritional information about orange-fleshed sweet potato in Uganda (Chowdhury et al., 2011) increased WTP. However, Zambian consumers who were informed about the chemical concentration in an unfamiliar water filter were no more likely than uninformed consumers to purchase the new filter (Ashraf et al., 2013), and information about the health risks associated with hookworm and the effectiveness of shoes to prevent it had no effect on WTP for rubber-soled shoes for children in Kenya (Meredith et al., 2013). Our experiment was characterized by a randomized information treatment that provided some participants with additional information about the potential long-term benefits of preventing maternal and early childhood undernutrition; the estimated effect of that information on WTP for LNS-P&L contributes additional evidence to the varied findings in the literature.

A number of studies have also explored the role of financial constraints in the adoption of preventative health and nutritional products. Tarozzi et al. (2014), for example, found that household ownership of bednets increased significantly over a one-year period in India among villages that had been offered the option of purchasing bednets on credit, and using randomized cash payouts, Meredith et al. (2013) found evidence suggesting liquidity was an important consideration in a household's decision to purchase rubber soled shoes to prevent hookworm in children. Although our experiment was not designed to directly evaluate whether easing financial constraints might increase demand for LNS-P&L, we use data on household income, asset ownership, and access to credit to assess the relationship between these potential indicators of binding financial constraints and initial WTP for LNS-P&L.

The timing and sizes of the expected streams of costs and benefits associated with LNS-P&L may also increase the likelihood that households will underinvest in the supplement. In particular, the costs associated with consuming LNS-P&L regularly as prescribed, which may include the opportunity cost of time spent procuring LNS-P&L and mixing it with food as recommended, perceived unpleasant physical side-effects associated with its consumption, and, if not fully subsidized, an out-of-pocket cost, are incurred well before many of the expected benefits are realized (e.g., economic returns to a child's improved physical and cognitive ability in adulthood). Furthermore, many of the more immediate expected benefits, such as improved maternal micronutrient stores and higher infant birth weight, may be difficult for households to observe and directly attribute to LNS-P&L. Within this context, it may be particularly important to identify effective mechanisms to help households overcome insufficient information and financial constraints.

3. Setting and experimental design

3.1. Research setting

The experiment took place in the Manya Krobo District in the Eastern Region of Ghana, approximately 75–80 km northeast of the capital city, Accra. The district features a busy commercial corridor, and many households are primarily engaged in small-scale petty trade. Rates of maternal and early childhood undernutrition in this particular region of Ghana are, in general, comparable to national rates. In 2011, 10.7% and 10.6% of babies born in Ghana and in the Eastern Region, respectively, were low birthweight, defined as weighing less than 2.5 kg at birth (Ghana Statistical Service, 2011). Among all children under five in Ghana in 2011, 22.7% were stunted,[4] while the rate of stunting among children under five in the Eastern Region was 21.3% (Ghana Statistical Service, 2011). Rates of anemia in pregnant and breastfeeding women in Ghana in 2008 were 70% and 62%, respectively (Ghana Statistical Service, 2009).

[3] Analyses of maternal outcomes and of the growth and cognitive development of the target infant are forthcoming.

[4] Children with a height-for-age z-score of < -2 SD below the median of the reference population are considered stunted. Height-for-age is a cumulative measure of nutritional status and reflects the effect of chronic undernutrition on linear growth (O'Donnell et al., 2007).

Table 1
Characteristics of women screened for participation

Variable	Definition	Mean/percentage		
		Not recruited	Recruited but did not participate	Recruited and participated
Pregnant	= 1 if pregnant (= 0 if breastfeeding a child under 6 months old)	90.2%	92.4%	94.8%
Weeks pregnant	Gestational age of pregnancy at screening in weeks	25.37	24.18	24.6
Used supplement	= 1 if previously used a nutritional supplement while pregnant or breastfeeding	58.8%	60.9%	67.6%
Transport price	Price of transport from home to prenatal clinic in 2011 USD	1.07***	0.77	0.77
Transport time	Minutes taken to travel from home to prenatal clinic	51.07***	37.7	38.9
N	Number of women	51	92	213

Significance codes: *** ($P < 0.01$), ** ($P < 0.05$), * ($P < 0.1$) indicated difference in means between women who were not recruited (column 1) and women who were recruited (columns 2 and 3) and difference in means between recruited women who did not participate (column 2) and did participant (column 3).

Recruitment for the experiment, which ran from approximately March to July of 2011, took place at a prenatal clinic at Akuse Government Hospital. At recruitment, all women[5] receiving pre- or postnatal services who were pregnant or breastfeeding a child six months of age or younger were read a brief statement about LNS-P&L and were told that their task in the experiment would simply be to decide how much LNS-P&L was worth to them. In total, 356 pregnant or breastfeeding women were screened for participation in an experimental session. Of those screened, 51 (14%) were either ineligible[6] ($n = 35$) or uninterested ($n = 16$) in participating. Eligible and interested women ($n = 305$) were asked to return to the prenatal clinic for the next session, which was typically within the next 48 hours.[7] Of those recruited, 213 (69.8%) ultimately participated. Recruitment took place outside the iLiNS project randomized controlled trial catchment area, so participants were not part of the iLiNS randomized trial[8] and had no previous knowledge of LNS-P&L, which was confirmed with each woman at recruitment.

Table 1 compares basic characteristics of women who were screened but not recruited for an experimental session to women who were screened and recruited but did not participate in a session and to those who were screened, recruited, and did participate. Because we observe only a few characteristics for those who did not participate, we are limited in the comparisons we can make across these groups. To a large extent, the average characteristics of women who were screened are similar across the three groups. Two exceptions are transport price and transport time from a woman's home to the prenatal clinic where screening took place and the sessions were held. These differences are not unexpected, as both the monetary cost and the opportunity cost of a woman's time to attend a session increase the farther she lives from the site where sessions were held. As long as women who live further away are not systematically different from those who live closer to the clinic, this should not bias our results. Given that the area around the clinic is largely homogeneous, we expect this to be the case. Among the subset of recruited women, there are no statistically significant differences between women who did and did not ultimately participate, although again this comparison is limited to the questions asked at recruitment and therefore we cannot assess the extent to which differences across, e.g., level of education or income exist between women who did and did not participate.

Variable definitions and summary statistics for the characteristics of participants and their households are presented in Table 2. The data on household income were elicited by asking participants the following: "Including wages, salaries, self-employment, and any other source of income, which of the following income group best describes the total combined income of your household last month?" Participants who reported a combined household income of under GH¢100 (approximately $65), which was the lowest income group option, were categorized as having low monthly income. The household asset index was constructed using principal component analysis (using the first principal component) of household ownership of a set of assets such that a higher score indicates a better relative

[5] During the recruitment period, recruitment took place during all hours of operation every day the prenatal clinic was open.

[6] Women were deemed ineligible to participate if they were not pregnant or breastfeeding a child under six months of age, if they were part of the main iLiNS study (see footnote 8), if they had previously participated in one of our experimental sessions, if they were asthmatic, or if they had a peanut or milk allergy.

[7] The composition of participants in each experimental session was, essentially, random. Women were assigned to an experimental session at recruitment (they did not self-select into particular sessions) and did not have any knowledge of other women assigned to their session.

[8] The decision to limit the experiment to women not participating in the iLiNS study was because (1) some of the iLiNS study participants received LNS-P&L for free as part of the study and would therefore not have an incentive to buy it, and (2) we did not want to introduce LNS-P&L into households randomized into the non-LNS-P&L arms of the iLiNS study.

Table 2
Participant and household characteristics

	Variable	Definition	Mean/ frequency	Std Dev/ percent	Min, Max
Participant characteristics	Head of Household	=1 if participant is head of household	28	13.2%	
	Age	Participant's age	27.7	6.3	17, 44
	Education	Participant's years of education	6.7	3.7	0, 15
	First Child	=1 if the participant is pregnant with or breastfeeding her first child	48	22.5%	
	Pregnant	= 1 if the participant is pregnant (= 0 if breastfeeding a child under 6 months old)	202	94.8%	
	Thin Baby at Birth	= 1 if any baby in the participant's household was thin/low weight at birth	30	14.1%	
Household characteristics	Low Monthly Income	=1 if the participant reported total combined household income of < $65 USD in previous month	45	21.1%	
	Asset Index	Proxy measure of socioeconomic status based on asset ownership	0	1.0	−1.8, 2.7
	HFS Score	Household Food Security Score	4.8	4.1	0, 15
	Borrowed For Food	= 1 if the household borrowed on credit to purchase food in the past 12 months	28	13.2%	

$N = 213$.

socioeconomic status (Vyas and Kumaranayake, 2006).[9] Food security data were collected using an abbreviated version of the Household Food Insecurity Access Scale developed by USAID's Food and Nutrition Technical Assistance (FANTA) project (Coates et al., 2007). Each household received a score between 0 and 15 based on the sum of five frequency-weighted[10] household food insecurity conditions[11] experienced the four weeks prior to interview. A higher score indicates more severe food *in*security.

3.2. Experimental design

A total of 44 sessions, composed of anywhere from two to 13 participants, were conducted between March and July of 2011 at Akuse Government Hospital in a private room near the prenatal clinic. A summary of the experimental procedure is presented in Figure 1, and the full protocol is available in Online Appendix C. As participants arrived they were assigned an enumerator[12] to record their bids and answer questions (the enumerator to participant ratios ranged from 1:1 to 1:3 across sessions), and participants were given GH¢ 4 (approximately $2.67) as compensation for their time.[13] Participants were told the money, which is roughly equivalent to a day's wage, was theirs to keep and they could chose to spend it however they wanted.

A Becker-DeGroot-Marschak (BDM) procedure was used to elicit WTP, which disconnects a participant's bid from the price paid for the item (for a detailed comparison of the BDM procedure to other mechanisms see Lusk and Shogren (2007)). Essentially, participants submit a bid for an item and then a market price is randomly determined. If a participant's bid is equal to or above the market price, she purchases the item at the market price. If her bid is below the market price, she does not receive the item and pays nothing. The BDM procedure has been shown to work well in African contexts,[14] it provides flexibility in that the number of participants in a session does not influence the outcome of the experiment for each individual participant, and it provides an incentive for participants to reveal

[9] The assets included in the index are sewing machine, stove, refrigerator, fan, cell phone, radio, computer, television, bicycle, motorcycle/scooter, and car.

[10] Following the guidelines in Coates et al. (2007), the frequency variable was coded as zero if the household did not experience a particular condition in the past four weeks. It was coded as one if the condition was experienced 1–2 times, coded as two if experienced 3–10 times, and coded as three if the condition was experienced more than ten times in the past four weeks.

[11] The conditions were related to (1) worry about not enough food, (2) insufficient resources to eat preferred foods, (3) limited resources leading to a limited variety of foods consumed, (4) limited resources leading to consumption of undesirable foods, and (5) limited resources necessitating smaller meals.

[12] Enumerators were members of the iLiNS Project team who were trained and experienced in collecting socioeconomic data. Prior to the experiment, the enumerators also received additional training to ensure they understood the objective of conducting the experiment, how the BDM mechanism is used to elicit incentive-compatible WTP, and how to interact with participants during sessions.

[13] In addition to travel time to and from the venue (which varied by participant as summarized in Table 1), the time required to participate in an experimental session was typically 70 minutes including the session itself and administration of the post-session questionnaire. The compensation of an average day's wage was chosen to be high enough to avoid truncating bids and to adequately cover the opportunity cost of time for the 'average' participant, given the variation among participants in travel time to the site of the experiment, income level, and other socioeconomic characteristics.

[14] Morawetz et al. (2011) introduce a variant of the standard BDM mechanism they call first-price BDM mechanism. The standard BDM mechanism (which is essentially a second-price mechanism) has been shown to work just as well as the first-price BDM mechanism in African contexts in terms of generating comparable average bids with similar levels of variance. As noted in Morawetz et al. (2011), the first-price BDM mechanism is not incentive compatible but may have been preferable to the standard BDM if it had been shown to have lower variance and/or less susceptibility to biases.

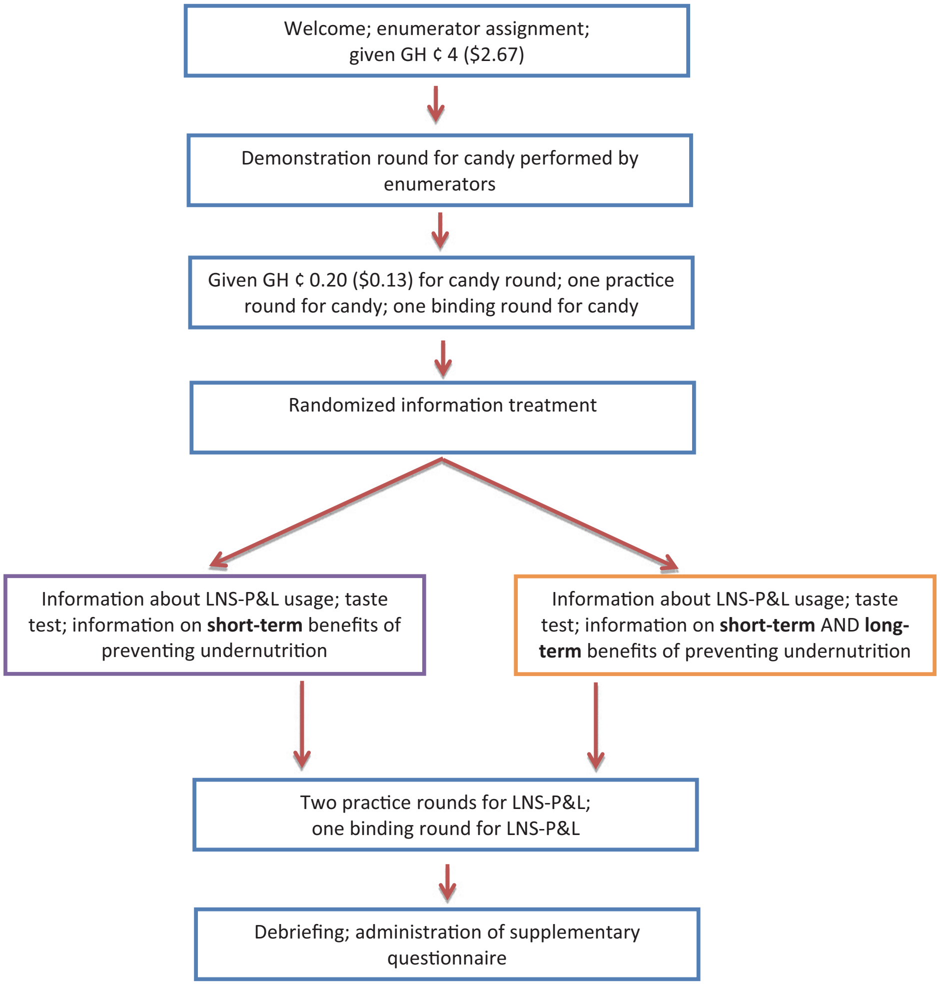


Fig. 1. Flow diagram of experimental procedure.

their true reservation price as their bid (Becker et al., 1964; Lusk and Shogren, 2007).

The experimental sessions were managed by a facilitator, and in an effort to make each session as similar as possible, the facilitator was the same person for each of the 44 sessions. Each session began with two practice rounds for candy to familiarize participants with the BDM procedure. Participants were given an additional 20 pesewas (approximately $0.13) for use in the final, binding candy round. Then, participants were read an information statement about LNS-P&L; the content of the information statement varied randomly across sessions.[15] In a randomly selected half of the sessions, participants were read information about LNS-P&L usage,[16] participated in a (voluntary) taste test, and were read information about the short-term benefits of preventing undernutrition. In the other half of the sessions, participants received all this information *plus* additional information about the potential long-term benefits of preventing undernutrition, focused on schooling attainment and economic productivity in adulthood. This randomized information treatment (full text available in Online Appendix C) was designed to test the impact of drawing participants' attention to the potential long-term benefits of consuming LNS-P&L during their pregnancy and while breastfeeding on their valuation of the product. Because all participants received information about short-term benefits and only information about long-term benefits was randomized, this test captures the effect of the additional long-term benefit information and is unable to separately estimate the impact of short- and long-term benefit information.

Participants were then led through two practice rounds for a week's supply (seven 20-gram sachets) of LNS-P&L. After each practice round, participants were given a chance to ask

[15] Balance tests for differences across the two information treatment groups show no statistically significant differences in any of the characteristics in Table 2.

[16] The information provided on usage included that women could take LNS-P&L every day throughout pregnancy and the first six months of breastfeeding to help ensure proper nourishment of the mother and her baby. Given the intended duration of usage, the fact that the item bid on was a week's supply of LNS-P&L and the product was not available outside of the experiment may have influenced participants' WTP. At the end of this section, we discuss this and other characteristics of our experiment that may have influenced WTP.

their assigned enumerator questions and discuss their bid in comparison to the random market price. These exchanges were private (between an individual participant and her enumerator only), and enumerators were instructed to provide clarification to participants but to avoid providing advice or passing judgment on a participant's bid in any way. After the practice rounds, the final, binding round for a week's supply of LNS-P&L was conducted. In each of the practice rounds and the binding round, participants (privately) submitted bids for LNS-P&L to their assigned enumerator, and after each bid was submitted, a random market price was determined by blindly selecting a slip of paper printed with a price. Market prices were drawn from a normal distribution with a mean of GH¢ 2 (approximately $1.33) and standard deviation of GH¢ 0.90 (approximately $0.60).[17] Participants were not directly told the distribution of prices. However, in an effort to reduce the effect of the practice rounds prices on participants' real bids for LNS-P&L, during the practice rounds participants were exposed to a range of random market prices that gave them a sense of the price distribution.[18] Participants were told directly that the potential and practice prices should not influence how much LNS-P&L was worth to them, but such effects are common in similar experiments so we control explicitly for practice round prices and outcomes in our empirical analysis.

Overall, 58.7% of all participants bid high enough to purchase LNS-P&L in the binding round. The sessions concluded with a short questionnaire to gather individual and household socioeconomic characteristics. Enumerators then ranked their assigned participants' comprehension of the BDM procedure on a scale of 1–5, where one was a poor understanding and five was an excellent understanding. The average comprehension rating was 4.3, indicating enumerators' perception of the participants' understanding of the BDM procedure was generally good.

Several aspects of the experimental design and nature of the product merit further discussion because of the potential to influence bids. First, LNS-P&L was a completely novel product to participants. As explained in Shogren et al. (2000) and formalized in Alfnes (2007), the value of 'preference learning', or the value in simply learning how an unfamiliar product fits into a consumer's preference set, can result in inflated bids. As previously noted, we recognize and, in fact, have evidence from another setting that demand for SQ-LNS is much more price sensitive for repeat purchases after the consumer has made an initial purchase and, presumably, learned a bit about the immediate costs and benefits associated with consuming the product. Given the one-shot nature of our experiment, we restrict our interpretation of the resulting estimates of WTP to what potential consumers might initially be expected to pay for LNS-P&L, which may very well include the value of preference learning.

A second concern is that the existence of market substitutes might censor bids to values below the market price of the substitutes (Alfnes, 2009; Harrison et al., 2004). Pharmacies and some local vendors sell a range of prenatal supplements and other pre- and postnatal products in Ghana, and as reported in Table 1, almost 68% of participants indicated they had previously used a nutritional supplement while pregnant or breastfeeding. The concern is that, as shown in Alfnes (2009), for a participant who considers a product available in the market to be a direct substitute for LNS-P&L, her optimal bidding strategy would be to bid below the expected market price of the substitute rather than her true valuation. While we recognize the market space for both information and nutritional products marketed to pregnant and breastfeeding women is quite crowded in Ghana, in many ways, LNS-P&L is very different from any product currently available on the market in Ghana. It is a food-based product embedded with micronutrients rather than a supplement consumed in tablet or powder form. Moreover, the research team collaborated with clinic staff during recruitment and during the experiment to assure participants that this was a new product developed specifically to meet the nutritional needs of pregnant/lactating women. So although no data are available on perceived substitutes, for these reasons we believe that participants likely perceived LNS-P&L as a distinct product from those available on the market, which reduces possible bias in bids.

Another concern is that the opportunity to resell LNS-P&L purchased in an experiment may influence a participant's optimal bidding strategy (Alfnes, 2009). We argue that in this particular case, the concern of resale is very low; there is no anecdotal evidence of resale, and because LNS-P&L was a completely unknown product in the area in which the experiment was conducted, the transactions costs associated with convincing people outside the experiment to purchase the product would have been prohibitively high.

A final set of concerns, which are common to most methods used to elicit WTP, are social desirability bias and item salience. Social desirability bias can occur when participants' bids reflect both their true WTP as well as utility derived from pleasing researchers with a high bid and/or creating an image as someone who cares a lot about the well-being of their children with a high bid (Lusk and Shogren, 2007). Item salience, in which the experimental context brings the item to the forefront of participants' minds, can also create an upward bias on bids,

[17] The price distribution was chosen to be in line with the estimated cost of producing the product (the mean of $1.33 was set at the estimated cost of production) and to avoid the potential of extreme outliers in the chosen random market price that would subsequently mean either almost all participants would 'win' or almost all participants would 'lose'. While it is possible that a high price draw in the practice rounds could create a higher anchor on subsequent WTP, this kind of anchoring has no overall effect on the WTP distribution with all sessions pooled together because the prices vary randomly across sessions. When estimating the determinants of WTP, we control for the prices drawn in practice rounds.

[18] Before the practice rounds, the facilitator drew a random market price from the bag and announced it to participants, and then enumerators privately discussed with their assigned participants whether they thought they would be willing to pay that price. This process was then repeated at least five times (without replacing previously drawn prices at each new draw) to demonstrate a range of possible market prices and to help participants begin thinking about how much LNS-P&L was worth to them.

as participants may underestimate the opportunity cost associated with procuring and consuming LNS-P&L outside of an experimental setting.

Taken together, these characteristics of experiments to elicit WTP in general and of our experiment to elicit WTP for LNS-P&L in particular imply that the absolute levels of WTP revealed during the experiment may reflect an upper bound on true initial valuation of the product.

3.3. Limitations

Before presenting our empirical models and results, it is important to describe some limitations of our experimental set-up. First, participants bid on a one-week supply of LNS-P&L, and because the product was not available outside the experimental setting, participants could not acquire more than the week's supply. WTP is therefore contingent on only being able to purchase a week's supply. Furthermore, some studies have shown that experimentation with a preventative health or nutritional product to learn first-hand about its costs and benefits is extremely important in helping convince households of the returns to investing in the product. Dupas (2014), for example, found that when households were given the opportunity to experiment with a new, long-lasting insecticide-treated bednet by providing it for free or at a highly subsidized price, WTP for another net a year later was higher. Beyond tasting the product, our set-up did not allow for any experimentation with LNS-P&L, so WTP in this case represents each woman's beliefs, conditional on her constraints, about the costs and benefits of LNS-P&L before she gained any personal experience using the product.

When interpreting our results it is also important to note the data are based on a sample of women who are not a random sample of the population of pregnant and breastfeeding women in this particular area of Ghana, which may have implications for the generalizability of our results. In particular, since all women who participated in an experiment were receiving formal pre- or postnatal care at a clinic, we might be concerned that their level of WTP as well as the factors associated with WTP might be different from women who do not seek formal care. This distinction is not particularly relevant in this case, however, since approximately 95% of women in Ghana receive at least some prenatal care during pregnancy and the rate is even higher at 96.4% in the Eastern Region (Ghana Statistical Service, 2009).

Finally, most of our participants came from within 10 km of the clinic where we staged the experiment. Thus, our sample is quite homogeneous, which has obvious implications for what we can learn about differences in demand. If we had been able to stage the experiment throughout several regions of Ghana—including the distinct and relatively poor northern regions—we would have much larger variation in individual and household characteristics. This broader variability in the data might change the significance of the demand differences that emerge in the present analysis. Even more importantly, a broader geographic scope would enable us to explore the effect of subsidies that target specific geographic regions, which can be both feasible and promising when geographic differences in demand are pronounced (see Lybbert, 2003).

Table 3
Average WTP for week's supply of LNS-P&L (2011 US dollars)[a]

	N	Mean (Std Error)	Std Dev	Min, Max	Zero Max WTP
Overall	213	1.74 (0.06)	0.87	0, 4.67	7 (3.3%)
Short-term benefits	115	1.75 (0.08)	0.88	0, 4.06	5 (4.4%)
Long-term benefits	98	1.73 (0.09)	0.87	0, 4.67	2 (2.0%)

[a]The estimated cost of producing a week's supply of LNS-P&L at a factory in Niger is $1.33.

4. Analysis and results

In this section, we use the WTP data to help characterize initial demand for LNS-P&L. We begin with summary statistics and an aggregate demand curve of WTP and compare these to preliminary estimates of the cost of producing LNS-P&L at a factory in Niger, which serves as a lower bound benchmark for possible market prices. Then, we model WTP in multivariate frameworks using ordinary least squares (OLS) and unconditional quantile regression methods to estimate the determinants of WTP. Results of the multivariate analysis provide insight into the factors systematically associated with WTP and suggest avenues through which policy efforts might address potential barriers to adoption and low demand.

4.1. Summary statistics

Table 3 summarizes WTP for a week's supply of LNS-P&L, and the raw WTP data are depicted as an aggregate demand curve in Figure 2. The average bid on seven sachets of LNS-P&L across all sessions and participants is $1.74 (2011 US dollars), which equates to roughly $0.25 per sachet of LNS-P&L. For participants exposed only to information about the potential short-term benefits of preventing undernutrition, the average bid on seven sachets of LNS-P&L is $1.75 (2011 USD), while the average is slightly lower (though not statistically different) at $1.73 for participants exposed to information on both the short- and long-term benefits of preventing undernutrition. Based on preliminary calculations, it would cost roughly $1.33[19] to produce a week's supply of LNS-P&L at a factory in Niger (preliminary results, authors' computations). The dashed line at approximately $1.33 in Figure 2 is this estimated production cost. Bearing in mind that this production cost estimate does

[19] The production cost estimates do not incorporate costs associated with transportation, marketing, etc., so these estimates are likely lower bounds.

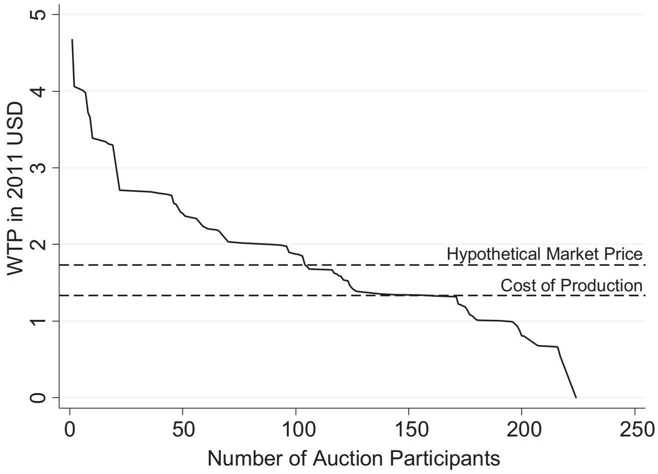


Fig. 2. Aggregate demand curve for LNS-P&L.

not include additional costs associated with transportation, distribution, marketing, etc., approximately 69.4% of participants value a week's supply of LNS-P&L at \$1.33 or more, indicating they would be willing to pay at least that much for the product. We can also use the preliminary product cost estimate as a lower-bound benchmark and assume various percentage markups on the final market price over the production cost. If we assume transportation, marketing, etc. will increase the price by 30% over the production cost, the market price is \$1.73 for a week's supply of LNS-P&L (also shown in Fig. 2). Our results suggest that less than half of our sample (approximately 46%) would purchase it at this market price.

4.2. Ordinary least squares

To build on this descriptive assessment of WTP for LNS-P&L, we now use regression to shed light on the determinants of initial demand. In this sub-section, we use OLS[20] to estimate WTP as a function of several participant, household and session variables. These OLS results are presented in the first column of Table 4. While each session was conducted by the same person and pre-testing and training emphasized uniformity across all sessions,[21] the composition of a particular session, questions that arose during a session, or other session-specific factors could lead to correlation in bids among participants in a particular session. We therefore cluster standard errors at the session level (Cameron and Miller, 2015).[22] Thus, we model WTP across $i = 1, 2, \ldots, N$ participants and $s = 1, 2, \ldots, S$ sessions as $WTP_{is} = X'_{is}\ \beta + u_{is}$ where WTP_{is} is willingness-to-pay for a week's supply of LNS-P&L for participant i in session s, X_{is} is a vector of observed individual, household, and session characteristics including controls for the random market price and whether participant $i's$ bid was higher than the market price in the practice rounds, and u_{is} is the error term.

We present OLS results for variables of interest in the first results column of Table 4. The unreported coefficients on control variables are jointly significant (F = 19.4) and help to net out potential confounding factors.[23] Among the participant characteristics, if a participant is pregnant with or breastfeeding her first child, her initial WTP for a week's supply of LNS-P&L is estimated to be approximately \$0.50 higher ($P < 0.01$) on average than a participant who has other children, all else constant. Our finding agrees with the finding in Hoffmann et al. (2009) that WTP for an insecticide-treated bednet is negatively related to the number of children under five years of age in the household, which the authors attribute to the quantity-quality tradeoff among children in the household.[24] Pregnancy is also significantly associated with WTP. If a participant is pregnant, her initial WTP for a week's supply of LNS-P&L is \$0.58 lower ($P < 0.01$) on average than if she is breastfeeding, holding all other variables constant. Because pregnancy outcomes,

[20] Although WTP is potentially left-censored at zero, we observe only seven bids (3%) of zero, so we use OLS to estimate the determinants of WTP, which does not depend on the assumptions of normality and homoskedasticity for consistency. In general, OLS estimates of censored data are inconsistent because the conditional mean of censored data differs from that of uncensored data (Cameron and Trivedi, 2005). As a result, WTP data are often estimated using a tobit maximum likelihood estimator (Lusk and Shogren, 2007), which is consistent under the assumption that the errors are normally distributed and homoskedastic. If these assumptions are violated, however, tobit estimates are inconsistent. Using Lagrange multiplier tests based on the tobit generalized residuals and scores, the assumptions of normality and homoskedasticity are both rejected at the 1% level (Cameron and Trivedi, 2010). Our regression results do not change in any substantial way when we estimate WTP using a tobit framework.

[21] For instance, participants were asked not to talk amongst one another, participants were seated such that there was an enumerator between participants, and bids were reported and recorded privately.

[22] Alternatively, we could include session dummy variables to control for session fixed effects. We opted not to do this since we have 44 sessions (some of which are composed of just two or three women), resulting in a large loss of degrees of freedom. Additionally, apart from what happened during a particular session, there are no outside factors (e.g., location of household, group membership, etc.) that would connect participants in a particular session in any way.

[23] The direction of these control variable effects is largely as expected. Participant comprehension of the BDM procedure increases WTP. The randomly drawn price in the practice round is positively correlated with WTP, suggesting some anchoring on this price. Participants who would have purchased LNS-P&L in the practice round similarly bid more in the binding round. Note that the fact that practice round prices have an effect on participants' WTP does not undermine the unconditional WTP distribution because these practice prices are random and centered on realistic LNS-P&L prices. While these prices do increase WTP for some individuals and decrease others, by controlling for these effects we are able to net out these effects so that the reported coefficients do not suffer from omitted variable bias. Finally, the enumerator fixed effects are jointly statistically significant.

[24] The quantity-quality tradeoff, first introduced by Becker (1960) and expanded in Becker and Lewis (1973), refers to the economic theory in which the interaction between quantity and quality in a household's budget constraint means an increase in the number of children in the household is associated with an increase in the marginal cost associated with investing in the quality of each child, creating a tradeoff between the number of children and the quality of each child.

Table 4
OLS and UQR results: WTP for a week's supply of LNS-P&L

	Variable	OLS[a]	Quantile[b] 0.10	0.25	0.5	0.75	0.90
Participant characteristics	Head of household	0.125	–0.355	0.049	0.016	0.321	0.373
		(0.174)[c]	(0.303)	(0.191)	(0.226)	(0.235)	(0.464)
	Age	0.005	–0.010	–0.005	0.008	0.014	0.005
		(0.008)	(0.017)	(0.011)	(0.015)	(0.015)	(0.021)
	Education	–0.030**	–0.007	–0.020	–0.011	–0.018	–0.070
		(0.015)	(0.031)	(0.020)	(0.022)	(0.031)	(0.045)
	First child	0.497***	0.152	0.226	0.456**	0.504**	0.580
		(0.139)	(0.216)	(0.171)	(0.226)	(0.256)	(0.359)
	Pregnant	–0.578***	0.149	–0.298	–0.347	–0.807**	–1.027*
		(0.213)	(0.491)	(0.290)	(0.427)	(0.397)	(0.622)
	Thin baby at birth	0.236	0.496**	0.106	0.278	0.086	0.491
		(0.141)	(0.215)	(0.222)	(0.266)	(0.229)	(0.439)
	Used supplement	–0.079	0.126	–0.157	–0.108	–0.129	–0.051
Household characteristics		(0.088)	(0.165)	(0.140)	(0.140)	(0.163)	(0.253)
	Low monthly income	–0.367***	0.221	–0.023	–0.454*	–0.560**	–0.877**
		(0.125)	(0.199)	(0.142)	(0.233)	(0.256)	(0.425)
	Asset index	0.134**	0.201*	0.159*	0.081	0.053	0.134
		(0.055)	(0.112)	(0.088)	(0.089)	(0.079)	(0.086)
	HFS score	0.007	–0.012	0.022	0.006	0.006	0.007
		(0.014)	(0.019)	(0.019)	(0.019)	(0.022)	(0.030)
	Borrowed for food	0.252*	0.478*	0.256	0.521***	0.387	–0.216
		(0.130)	(0.288)	(0.202)	(0.199)	(0.289)	(0.435)
	Information treatment	–0.034	–0.111	–0.193	–0.087	0.007	0.019
		(0.086)	(0.194)	(0.124)	(0.153)	(0.137)	(0.294)
	Constant	0.576	–0.597	0.137	–0.700	1.177*	2.871**
		(0.366)	(1.058)	(0.818)	(0.673)	(0.657)	(1.323)
	R^2	0.432	0.215	0.283	0.302	0.272	0.227
	Mean/quantile	1.738	0.677	1.194	1.669	2.188	2.688

$N = 213$.
Significance codes: *** ($P < 0.01$), ** ($P < 0.05$), * ($P < 0.1$).
Note: Controls for enumerator, participant comprehension of the BDM procedure, market price in the last practice LNS bidding round, and whether the participant would have purchased LNS-P&L in the last practice round are also included in model (unreported).
[a]Standard errors are clustered at the session level.
[b]Standard errors for quantile regressions were obtained over 400 bootstrap replications clustered at the session level.
[c]Numbers in parentheses are cluster-robust standard errors.

particularly in developing country settings, are subject to uncertainty, this relationship is sensible since a woman may be less inclined to invest in the health of a child before she has observed the outcome of her pregnancy. Once that uncertainty is resolved with the arrival of the baby,[25] investments in the health of her baby become more salient.

Finally, education is negatively related to initial WTP, though the magnitude of the effect is small; on average, WTP is estimated to be $0.03 lower for each additional year of education, suggesting that a one standard deviation increase in education (3.74 years) decreases WTP by about $0.11. The findings in the literature on the role of education are mixed. While Chowdhury et al. (2011) find a positive relationship between education and WTP for orange-fleshed sweet potato in Uganda, Berry et al. (2015) find that in Ghana, people who have attended school have a lower WTP for a water filter than those who have never attended school. Other participant characteristics, including the participant's position in the household, age, and personal experience using a nutritional supplement, are not statistically significantly related to WTP.

Turning now to household characteristics, household income is a statistically significant predictor of initial WTP for LNS-P&L. If a household's self-reported, combined income is less than $65 per month (2011 USD), WTP is, on average, approximately $0.37 lower ($P < 0.01$) than for households with monthly incomes above $65, reflecting the importance of a household's budget constraint in determining WTP. The asset index, another measure of a household's socioeconomic status, is also statistically significant, where better-off households, as indicated by a higher asset index score, have a higher WTP, *ceteris paribus*. In contrast to the 'low income' dummy variable, the asset index – a continuous variable constructed to

[25] As an example of this uncertainty, one expectant father in an early focus group compared an unborn child to a mature cassava plant with the soon-to-be-harvested tuber hidden beneath the soil.

have a standard deviation of 1 – provides a broader measure of household wealth. This measure of wealth strongly affects households' WTP. This wealth effect suggests that participants may consider LNS-P&L to be more of a luxury than a necessity, but the precise mechanism that relates wealth to WTP remains an open question.

Participants whose households borrowed money in the previous year in order to purchase food have an approximately \$0.25 higher ($P < 0.10$) WTP for LNS-P&L on average than households who did not purchase food on credit, suggesting that access to credit for routine consumption purchases might play a role in determining households' initial valuation of LNS-P&L. While this variable might also proxy for desperation in food purchases, the composite household food security variable provides a more direct measure. The fact that food security is insignificant after controlling for other measures of household wellbeing but borrowing for food purchases is significant suggests that less binding liquidity constraints matter more to initial demand for LNS-P&L than does food security per se.

Finally, we turn to the role of information about the long-term benefits of preventing undernutrition on WTP. The effect of the long-run benefit information, which was randomly assigned across sessions to provide some participants with long-run benefit information beyond the standard potential short–term benefits of preventing undernutrition, is not statistically different from zero. That is, initial WTP for LNS-P&L is not statistically different for women who were told about the potential impact of nutritional status during pregnancy and in early childhood on long-term human capital accumulation and adult earnings than for women who did not receive this information. Based on the way the information was presented and given the idiosyncrasies previously discussed, additional information about these long-term benefits does not (conditionally) translate into a statistically significantly higher valuation of LNS-P&L. Because the experiment was not designed to separately estimate the valuation effect of short- and long-term benefit information, we cannot infer anything about the impact of information about short-term benefits.

4.3. Unconditional quantile regression

Based on a linear conditional mean function, $E(y|x)$, OLS estimates the average relationship between a particular covariate and the dependent variable, which constrains the nature of the relationship to be the same over the entire distribution of the dependent variable (Koenker and Hallock, 2001). This average response, however, is only a partial view of the relationship, and, depending on the policy questions being addressed, may provide misleading or incomplete information about the effect of a particular variable on the outcome of interest.

Unconditional quantile regression (UQR) techniques, proposed by Firpo et al. (2009), allow for the possibility that the size and nature of the relationship between a covariate and the dependent variable may differ from the mean effect at different points along the unconditional distribution. That is, UQR allows us to estimate the marginal effect of a small change in an explanatory variable on a specific quantile of the unconditional distribution of the dependent variable.[26]

UQR is based on the two-step estimation procedure outlined in Firpo et al. (2009). First, a re-centered influence function (RIF) is estimated, where $RIF(y : q_\tau) = q_\tau + IF(y : q_\tau)$. Here, q_τ is the τth quantile, and $IF(y : q_\tau)$ is what is known as the influence function, defined as

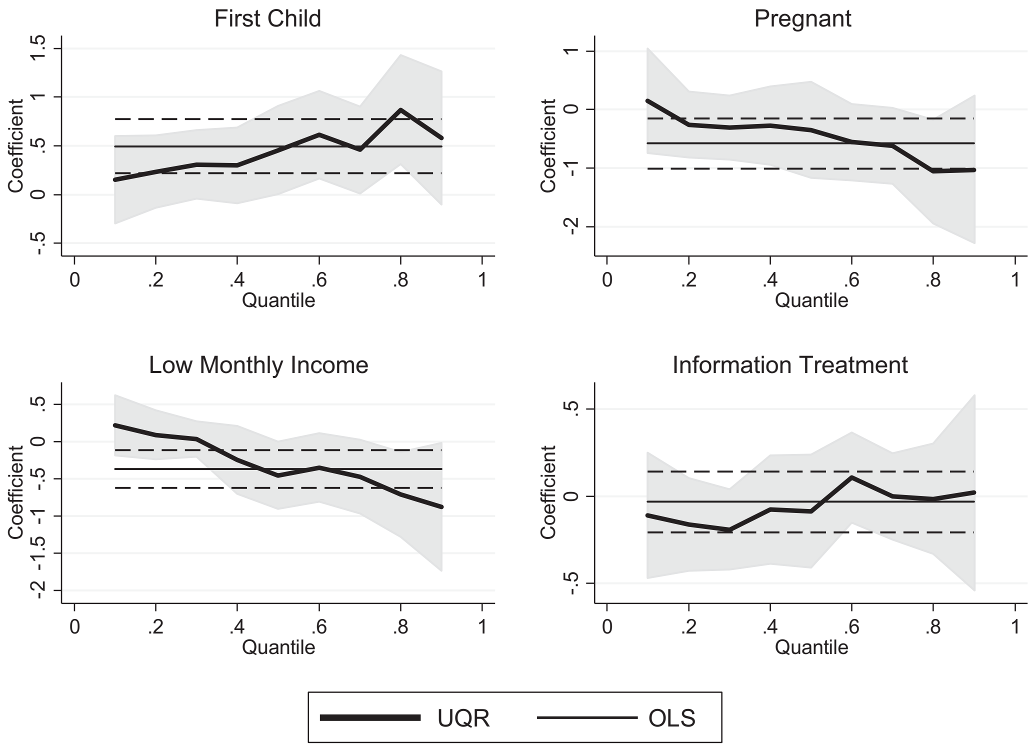
$$IF\ (y; q_\tau) = \begin{cases} \dfrac{\tau - 1}{f_y\,(q_\tau)}, & y \leq q_\tau \\ \dfrac{\tau}{f_y\,(q_\tau)}, & y > q_\tau \end{cases}$$

where $f_y(q_\tau)$ is the density of the dependent variable y (WTP in our case) at q_τ estimated using a kernel density estimator. The influence function of a particular quantile, as described by Firpo et al. (2009), is the influence of an individual observation on that quantile. The influence function is then recentered by adding back the τth quantile. The second step is then to regress the RIF on the set of covariates using OLS to obtain coefficient estimates, $\hat{q}_\tau$, for the τth sample quantile.

We estimate a set of UQR models (at the 10th, 25th, 50th, 75th, and 90th quantiles) with bootstrapped standard errors clustered at the session level (Table 4). Plots of the UQR at every 10th quantile and OLS coefficients for key variables are displayed in Figure 3.

The UQR estimates provide evidence that the size and significance of factors associated with WTP for LNS-P&L are, in some cases, not constant across the distribution of WTP, and therefore unconditional quantile regression analysis provides a more comprehensive characterization of the determinants of WTP than OLS. We see heterogeneity across the distribution of WTP in the size and significance of the marginal effect of being pregnant with or breastfeeding one's first child. The effect is small (and insignificant) below the median of the unconditional distribution of WTP, but at the 50th and 75th quantiles, the effect of being pregnant with or breastfeeding a first child is large and statistically significant. Keeping in mind that preliminary production cost estimates are \$1.33 for a week's supply of LNS-P&L, which falls between the 25th and 50th

[26] This is in contrast to (conditional) quantile regression, introduced by Koenker and Basset (1978), in which the marginal effect is an estimate of a very small change in an explanatory variable on a specific quantile of the conditional distribution. That is, it estimates the marginal effect of a change in an explanatory variable on a specific quantile *after* conditioning on other covariates at a particular value (commonly the mean) and assuming that the conditional quantile of a particular individual/observation does not change with the change in the explanatory variable, making it more difficult to interpret the conditional coefficients than the unconditional coefficients (Fournier and Koske, 2012). As pointed out in Firpo et al. (2009), if the conditional and unconditional distributions are very similar, then the difference in the conditional and unconditional regression estimates will be small. However, when the conditional and unconditional distributions are more dissimilar, there will be large differences in the estimated coefficients across the two methods.



Note: 95% confidence intervals are represented by dashed lines for OLS coefficients and shaded areas for UQR coefficients.

Fig. 3. OLS and UQR coefficients with 95% confidence intervals.

quantiles of WTP, this result has potentially important policy implications, since the relationship between WTP and having a first child is smaller and insignificant at the lower end of the distribution where subsidization might be necessary to boost demand.

As the OLS results suggest, the UQR estimates also generally show that women who are pregnant have a lower WTP for LNS-P&L than women who are breastfeeding. However, we again see heterogeneity across the distribution, where the magnitude of the estimated coefficient is substantially larger (and significant) for women at the 75th and 90th quantiles. Finally, we see that having previous experience with a baby who was thin or low birthweight when s/he was born has a positive and significant effect on WTP for women at the 10th quantile, a significant relationship that is concealed by OLS.

Turning to household characteristics, the UQR results show that low income levels are associated with a lower WTP for LNS-P&L, but this relationship is only statistically significant at the median value of WTP and above. This result is important because it potentially suggests that for women in the lower tail of the WTP distribution, it is not necessarily the household's budget constraint that is driving down their WTP relative to other women in the sample. The positive and significant coefficient on the household's asset index at the 10th and 25th quantiles (and not elsewhere on the distribution), however, suggests that there is something important about a household's socioeconomic status in determining WTP for women who value the product relatively less, and the asset index is picking up that relationship in a different way than the indicator for low monthly income.

Finally, the effect of the information treatment, which is very small in magnitude and not statistically significant in the OLS specification, varies across the distribution of WTP. The effect is positive, though imprecisely estimated, at the 75th and 90th quantiles and negative, though again imprecisely estimated, at the 10th, 25th, and 50th quantiles.

4. Implications for policy, pricing, and delivery

Although LNS-P&L and other nutritional supplements appear to be promising means of improving nutritional and health outcomes among malnutrition-prone households in some settings, these preventative products raise some challenging cost and delivery dilemmas (see Lybbert, 2011). These dilemmas stem from the fact that (targeted) free public distribution, which has worked remarkably well for RUTF to treat severe acute malnutrition, is an unrealistic delivery strategy for preventative products designed for daily consumption by a much broader group of beneficiaries over longer periods of time. This section describes how the results in this paper relate to these delivery dilemmas.

Many of the obstacles that will need to be overcome with regards to successful delivery of SQ-LNS to vulnerable populations stem from the duration of intended usage, and we recognize that our estimates of WTP for a single week's supply of LNS-P&L do not provide a comprehensive picture of persistent demand over the many months of intended usage. Indeed, as previously noted, preliminary results from a year-long market trial in Burkina Faso that partnered with local vendors to sell an SQ-LNS product for young children show that the elasticity of demand for repeat purchases of SQ-LNS is significantly higher than that of first-time purchases (Lybbert et al., 2016). Nevertheless, taken as an estimate of the upper bound on the long-run demand for LNS-P&L, our results indicate that while most women in our sample place a positive value on LNS-P&L, more than half would not purchase even an initial week's supply of the product if it were available at a price of 30% above current costs of production. Although production costs may fall over time as product value chains mature and as scale economies are realized, our results suggest that private demand alone will not likely be sufficient to sustain retail markets or to cover significant portions of the costs of providing LNS-P&L. If these products are shown to effectively reduce maternal and early childhood undernutrition, improve the health and development of children, and to generate intergenerational benefits and productivity gains, there may be compelling economic arguments for policy actions to bridge this gap between private demand and production, procurement, and delivery costs (Alderman, 2010; Hoddinott et al., 2013a).

The heterogeneity of demand for an initial week's supply of LNS-P&L that is evident in our data suggests targeted subsidies may help stimulate demand for the product where household-level valuation is low despite potentially high private returns. While the conventional regression analysis above sheds light on some of the determinants of demand, it does not generate direct implications for targeted subsidies because targeting cannot hold all else equal. Whereas these regressions allow us to test the effect of different variables on LNS-P&L demand *conditional* on other variables held constant (the familiar *ceteris paribus* assumption), targeted subsidies have to commit to a dimension along which heterogeneity is pronounced *unconditionally* and can be feasibly targeted. This implies that unconditional demand differences (so-called *mutatis mutandis*, "let all other variables change as they will") ought to be the basis of targeting (see Lybbert et al. (2013)).

With this distinction in mind, the implications of our results are easier to discuss. We find that education (–), first child (+), pregnant (versus breastfeeding) (–), low income (–), assets (+), and borrowing for food (+) conditionally shape initial demand for LNS-P&L. Of these relationships, three—first child, low income, and assets—are also significantly and *unconditionally* related to demand for LNS-P&L. This suggests that targeted subsidies that make the supplement cheaper for women with low income, low assets, or multiple children might reasonably expand the pool of consumers willing to purchase at least a week's supply of LNS-P&L in our study area.

At a more basic level, we can use these variables to consider how the price of LNS-P&L, which becomes a key decision variable under hybrid private-public delivery, might shape the

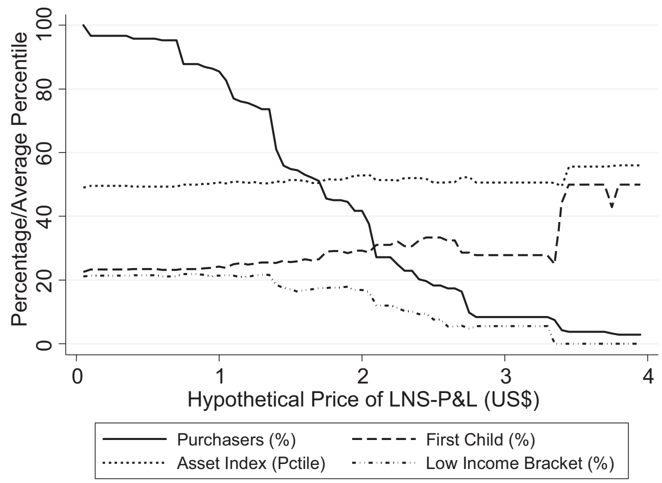


Fig. 4. Characteristics of buyers along an LNS-P&L price continuum.

characteristics of the pool of purchasers at different price points. Figure 4 shows the percentage of participants who, based on their bid, would be expected to purchase a week's supply of LNS-P&L at various price points—essentially an inverse demand curve—and summarizes purchasers' characteristics. At high price points, the pool of purchasers may include a large percentage of women who are pregnant with or breastfeeding their first child, a small percentage of women from low income households, and women from households with relatively high asset index scores. A subsidy to move the price of LNS-P&L left in Figure 4 would increase the number of purchasers and change the composition of the pool of purchasers to include more low income households, households with lower relative asset index scores, and more multiple-children households. As such, subsidies or short-term promotional activities could encourage more wide-spread demand for LNS-P&L by women with specific characteristics—women from low income households, for example—who would otherwise have been priced out of the market.

5. Conclusions

The failure of traditional diets and of available commercial and traditional dietary supplements to meet women's nutritional needs during pregnancy is common in the developing world, and research is demonstrating the large and sometimes irreversible health, developmental and economic consequences for their children. In the long term, reductions in poverty, improvements in agricultural and other markets, and a better understanding and articulation of dietary needs may resolve many nutrient intake problems. Meanwhile, changing dietary habits in ways and to the extents recommended by nutritionists may be challenging, especially among the resource-poor, so dietary supplements may have an important role to play in reducing some nutrient deficiencies, especially among pregnant women and young children. But how will these supplements be delivered, and, related, who will pay for them? Given the scale at which SQ-LNS products would have to be provided, untargeted provision free-of-charge will not be fiscally feasible. If fees, even small fees, are charged, then the relevant policy debate immediately shifts from one focused on nutritional needs to one focused on the demand for dietary supplements.

To be useful for SQ-LNS policy discussions, demand assessment tools must produce useful estimates, and do so quickly and cheaply. The BDM procedure presented here is a quick, affordable tool that provides an estimate of initial WTP for SQ-LNS. In another rural setting in West Africa, the Dandé Health District of Burkina Faso, estimates of WTP generated via a modified BDM procedure were in line with those measured at the outset of a market trial for an SQ-LNS product for children; if this association is robust, then policy makers will have a quick and accurate upper bound on WTP for SQ-LNS, regardless of the delivery platform selected.

If policy makers choose to promote SQ-LNS products, then having estimates of SQ-LNS demand will put them in a better position to take two fundamental decisions: (1) what delivery platform(s) to use, and (2) how much of the costs of procuring/delivering SQ-LNS should be allocated to consumers? If demand among vulnerable populations is sufficient to cover all procurement and delivery costs, and also to provide an acceptable profit margin for vendors, then a retail platform may be the most cost-effective delivery platform, and policy makers need only remove legal and other obstacles to the production and distribution of SQ-LNS. At the other extreme, if demand among vulnerable populations is very low, then retail distribution will not likely be possible and the fees that can be charged to consumers at other distribution platforms (e.g., public clinics) will be very low. In the ‘intermediate’ range between low demand and demand that is sufficient to sustain retail markets, it will be the policy maker’s choice of delivery platform, and this choice will be guided, in part, by the public sector costs associated with designing and managing alternative platforms. However, regardless of the choice of delivery platform(s), demand estimates provide insights into how much consumers are willing to pay to have access to these products, and consequently, how much other stakeholders will have to pay to guarantee this access.

Acknowledgments

This study is based on research funded by a grant to the University of California, Davis from the Bill & Melinda Gates Foundation. The findings and conclusions contained within are those of the authors and do not necessarily reflect positions or policies of the Bill & Melinda Gates Foundation. We thank Anna Lartey and Seth Adu-Afarwuah, Boateng Bannerman and the data entry team in Accra, Harriet Okronipa and the iLiNS DYAD-G management team in Kpong, and the iLiNS DYAD-G SES enumerators for their work in the field. We also thank Mary Arimond and the iLiNS Steering Committee (http://ilins.org/about-ilins/who-we-are/ilins-steering-committee). Special thanks to the nurses at Akuse Government Hospital prenatal clinic for their willingness to work with us and help in facilitating recruitment and, notably, the women who participated in the study. Finally, we thank Kay Dewey for her valuable comments on an earlier draft. All errors are those of the authors alone.

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