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Household Demand for Child Micronutrient Supplementation in Burkina Faso

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Abstract

The success of Plumpy'Nut®, a ready-to-eat therapeutic food (RUTF), in treating severe acute malnutrition (SAM) revolutionized the *treatment* of SAM and sparked efforts to develop, test, and distribute small-quantity lipid-based nutrient supplement (SQ-LNS) products aimed at *preventing* undernutrition. The move from a targeted therapeutic RUTF to broadly distributed preventative SQ-LNS products designed for daily consumption will likely require the private sector to play more central production and delivery roles, which hinge on persistent private demand for these supplements. We use experimental markets for SQ-LNS in rural Burkina Faso to shed light on household demand for preventative SQ-LNS. In collaboration with local vendors, we conducted a 62-week market trial in 14 villages that enabled us to test the effects of both price and non-price factors on the persistence of household demand. We find that price elasticity of demand for these supplements is high on average, but that repeat purchases are more price-sensitive than first-time purchases. We also find that a loyalty card that offers a small reward to those purchasing an entire month's supply of SQ-LNS strongly boosts persistent demand. Both the price and non-price demand effects diminish after a few weeks, underscoring the challenge of persistent demand. In this rainfed agricultural context, rainfall fluctuations also shape demand in potentially important ways. Tapping the full potential of micronutrient supplements will likely require innovative supply chains and hybrid private-public delivery strategies that enable cost-sharing and efficiency gains.

Keywords: Undernutrition; Early childhood; Micronutrients; Supplementation; Demand; Burkina Faso.

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1 Introduction

In the past decade, a fortified peanut butter-based product called Plumpy'Nut® has seen remarkable success as a treatment for severe acute malnutrition (SAM) among young children. Showcased widely in popular media outlets, this success prompted several companies to formulate similar energy-dense products that also provide micronutrients and essential fatty acids in a lipid-based (typically, peanut) paste – products collectively known as Ready-To-Use Therapeutic Foods (RUTF) or 'large-quantity' Lipid-based Nutrient Supplements' (LNS). Rigorous evidence of the success and cost-effectiveness of LNS products in treating SAM (Ciliberto et al. 2005, Diop el et al. 2003) triggered a massive budgetary shift towards therapeutic LNS products by the three major childhood nutrition players: United Nations Children's Fund (UNICEF), *Médecins Sans Frontières* (MSF) and the World Food Programme (WFP).

This unprecedented success, coupled with increasing recognition of undernutrition as a top global health and economic development priority (Hoddinott et al. 2013b), has stimulated the emergence of a globally-recognized, coordinated framework for addressing undernutrition. At its center, the Scaling Up Nutrition (SUN) movement advocates multi-sectoral strategies to reduce undernutrition as complements to direct nutrition interventions such as therapeutic feeding, food fortification, micronutrient supplementation, and breastfeeding promotion (Nabarro et al. 2012, Scaling Up Nutrition 2012). While the revolutionary role of RUTF in treating SAM is clear, relatively recent advances in the understanding of the irreversible, long-term deleterious effects of less life-threatening forms of undernutrition has spawned broad recognition of the need to not only treat children suffering from SAM but also *prevent* undernutrition during the critical first 1,000 days of life (Arimond et al. 2013). Sustainable, long-term strategies to prevent undernutrition, including largely invisible micronutrient deficiencies described as 'hidden hunger', will likely be primarily food-based (e.g., dietary diversification and food fortification) (von Grebmer et al. 2014). In the short-term, however, supplementation can help meet the high nutrient requirements of pregnant and lactating mothers and of children from 6-24 months of age (Arimond, et al. 2013, Dewey and Vitta 2012). Marshaling the resources required to provide micronutrient supplements to vulnerable individuals remains challenging.

Within this context and fueled by a mix of public and private R&D investments, a decade of innovation has led to the emergence of three distinct and differentiated LNS product classes (see Table 1). 'Large-quantity' LNS such as Plumpy'Nut® are designed to provide 100% of a (9-12 month old) child's energy demands outside breast milk. 'Medium-quantity' LNS products (also known as Ready-to-Use *Supplementary* Foods (RUSF)) aim to treat moderate malnutrition and to prevent SAM, and are designed to be combined with other complementary foods and therefore provide 50-100% of energy demands. 'Small-quantity' LNS products (SQ-LNS) aim to prevent undernutrition and promote normal growth and are designed to provide <50% of energy demands. While the LNS product classes described in Table 1 may seem like different points on a continuum of formulations – a continuum created by simply dialing up or down different ingredients, daily ration sizes, or the frequency and duration of recommended consumption – some of these differences affect the costs of suggested interventions and may also bring

major supply chain implications. In this paper, we use experimental markets for SQ-LNS in rural Burkina Faso to shed light on these challenges and to explore the associated implications for distribution and for cost sharing.

The supply chain challenges we study stem from differences in how, how long, and why these nutritional products are consumed. Large-quantity LNS products are designed to be consumed intensively by children as part of a short-term emergency treatment regimen and are exclusively distributed via public channels. Indeed, in many countries, including Burkina Faso, it is illegal for individuals to buy or sell these products privately. In contrast, SQ-LNS products are designed to be consumed daily for extended periods of time to compensate for the lack of micronutrients and essential fatty acids in local diets, and hence guard against undernutrition. Key beneficiaries of these products are expected to be young children (aged 6-24 months), and pregnant and lactating women.

These differences in objectives and suggested consumption patterns have profound implications for supply chains, as suggested by Table 1. Whereas major public and private players have structured large- and medium-quantity LNS supply chains, helped coordinate purchases and delivery of products among nutrition stakeholders in the public, non-profit and private sectors, and largely covered all costs, they are unlikely to take the lead with SQ-LNS products for which demand is less certain, acceptable product specifications have not yet been agreed upon, and effectiveness and cost-effectiveness has not been systematically demonstrated (Lybbert 2011). Instead, any coordination that does emerge among stakeholders and supply chains may involve a mix of public and private sector engagement. Where and how such a hybrid distribution system emerges will reflect a host of site-specific factors, including nutritional needs, private sector presence and capacity, public health and other infrastructure, public sector commitments to providing necessary investments and coordination, and perhaps most importantly, private demand for SQ-LNS products.

Therefore, the potential evolution of SQ-LNS supply chains hinges critically on household demand for these products in the broader context of household food, nutrition and health choices, which may be even more pronounced among the poor as a thriving literature in development economics documents (Dupas 2011, Meredith et al. 2013). Understanding the nature of SQ-LNS demand sets the stage for designing, testing and scaling up production and delivery options and addressing cost-sharing issues. Specifically, by shaping which households purchase these products, how regularly children consume them, and how these consumption patterns translate into real health benefits, private demand for SQ-LNS products will determine the viability and sustainability of alternative hybrid public-private options for delivering daily supplements to the urban and rural poor. Household demand for these products thereby creates or constrains opportunities to leverage the comparative advantage and resources of public organizations and private firms.

This study focuses on Burkina Faso, a low-income country characterized by high rates of early childhood undernutrition and low levels of public and private spending on health. For several reasons, rural Burkina Faso is an ideal context for studying demand for micronutrient supplementation. The World

Bank estimates the 2014 Gross National Income per capita for Burkina Faso was $710, less than half the 2014 average of $1699 per capita for developing countries in Sub-Saharan Africa.[1] Of the approximately 3 million children under 5 in Burkina in 2012, 32.9% were stunted (height-for-age z-score < -2), 10.9% were wasted (weight-for-height z-score < -2), and 16.2% were born at low birthweight (< 2500g) (Ministere de la Sante et al. 2012). Meanwhile, from 2011-2015, average annual health expenditures, including both public and private expenditures, were $46 per capita in Burkina Faso, compared to $101 per capita in Sub-Saharan Africa.[2] Burkina Faso became a member of the Scaling Up Nutrition (SUN) movement in 2011 and has developed a 6-year, US$70.7m plan to address undernutrition (Scaling Up Nutrition 2014). Approximately 66% of the plan's budget has been allocated to nutrition-specific interventions, of which complementary feeding of young children in the SQ-LNS target age range (6-24 months) is an integral component.

This study is part of a broader International Lipid-Based Nutrient Supplement research program[3], and more specifically the iLiNS-Zinc nutrition trial in rural Burkina Faso that measured, among other things, the effects of an SQ-LNS product formulated for young children on their growth and development. Analysis of these clinical trial results show that these SQ-LNS products, when provided with monitoring and treatment of malaria and diarrhea to children from 6-18 months of age, improve linear growth, decrease the prevalence of both stunting and wasting, and positively affect some aspects of cognitive and behavioral development (Hess et al. 2015, Hess et al. 2013). When the nutrition trial concluded, we used experimental methods to measure private demand for SQ-LNS. In mid-2013, we designed and conducted experimental auctions for SQ-LNS in 14 villages in our study area. These auctions, which included some households that participated in the iLiNS-Zinc nutrition trial but primarily consisted of other (non-iLiNS-Zinc) households with children in the target age range (6-24 months), enable us to estimate complete, incentive-compatible demand curves for SQ-LNS. Immediately after conducting the auctions, we launched a market trial in the same 14 villages. The structure of this market trial allows us to estimate the price elasticity of demand for SQ-LNS overall, as well as for initial and repeat purchases separately. Subsequent phases of this market trial enable us to estimate the effects on demand of a loyalty card that offers a small reward to households that purchase a complete month's supply of SQ-LNS, including the gender-differentiated effects of this loyalty card. By merging these market trial data with high resolution rainfall data and with detailed endline data for a sub-sample of buyers, we are also able to estimate the sensitivity of demand to departures from normal rainfall and to selected household characteristics.

We make several contributions in this analysis, which builds on a thriving area of inquiry in development economics. We provide the first rigorous evaluation of persistent demand for a nutritional supplement in a developing country. We find that price elasticity of demand for SQ-LNS is high on average, but that elasticity for repeat purchases is significantly higher than for initial purchases. This has important implications for delivery design for SQ-LNS and other nutrition investments that require daily (or at least

[1] Sources: http://data.worldbank.org/country/burkina-faso and http://data.worldbank.org/region/SSA
[2] Sources: http://data.worldbank.org/country/burkina-faso and http://data.worldbank.org/region/SSA
[3] For details, visit the iLiNS website: http://www.ilins.org/

regular) consumption. In addition, even if SQ-LNS is cost-effective as a nutritional investment from a societal perspective, private demand may cover less than half the production and distribution costs of SQ-LNS, suggesting the need for mixed private-public delivery strategies and cost-sharing arrangements. Second, we estimate the impacts of a non-price factor on demand persistence. The estimated impact of a loyalty card on demand persistence enables us to directly compare price and non-price determinants of demand. Next, we are able to test how local rainfall shapes demand for SQ-LNS and find that above-normal rainfall in a given week induces greater demand, but only during late stages of the agricultural production season and primarily in villages with (randomly assigned) high prices. Finally, based on the subset of households that were included in an endline survey, we find that demand persistence is highest in wealthy households that purchase half or more of their food in markets. We conclude with a discussion of what these findings may mean for the design of production and delivery models for micronutrient supplements such as SQ-LNS, and the roles of public policy in helping ensure that the nutritional needs of young children, and of pregnant/lactating women, are met.

2 Background

2.1 Micronutrients and Child Development

The first 1,000 days in a child's life, beginning at conception and extending through his/her second birthday, have been identified as *the* critical window for preventing undernutrition (Black et al. 2013). Due in part to rapid growth and development, nutritional needs are very high in a child's first 1,000 days, and undernutrition during this vulnerable period increases the risks of morbidity and mortality, growth faltering, and impair motor and cognitive development (Dewey and Begum 2011, Martorell 1999, Victora et al. 2010). The long-term implications of early-childhood undernutrition can include shorter adult stature, deficits in schooling, lower economic productivity, and decreased offspring birthweight (Hoddinott et al. 2013a, Martorell et al. 2010, Victora et al. 2008). Beyond the moral imperative to provide children with adequate nutrition to thrive throughout their life-course, then, economic development hinges in many ways on improving maternal and early-childhood nutrition (Alderman 2010, Alderman and Behrman 2006).

While a food-based approach to improving dietary quality through increased and routine consumption of nutrient-rich foods is generally acknowledged as the preferred long-term solution to undernutrition, strategies that involve fortification and/or supplementation can be implemented in the short-term and help meet high nutrient needs of very young children during the period of complementary feeding from 6-24 months of age (Dewey and Vitta 2012). Fortified food blends that have been specifically formulated for young children represent one such option, but concerns about breastmilk displacement, high variability in the amount of the product (and therefore the quantity of nutrients) consumed, and the limited dietary diversity associated with relying on a single food has sparked the development of micronutrient powders and SQ-LNS, both intended for home fortification (Dewey and Vitta 2012). Compared to micronutrient powders, which contain only micronutrients and are intended to be added to food just prior to consumption, SQ-LNS products embed these micronutrients in a lipid base and

deliver energy, protein, and essential fatty acids and key macrominerals not contained in micronutrient powders (Arimond, et al. 2013). Moreover, the fat content of SQ-LNS may enhance the bioavailability and absorption of fat-soluble vitamins (Dewey and Vitta 2012).

While we have learned much in recent decades about key dimensions of child nutrition, important limitations to our understanding persist – limitations that are important as a backdrop to our analysis. Child growth and development are complex processes (Black, et al. 2013), and the individual and collective effects of the three general stressors to these processes (undernutrition, infections and disease) are not completely understood (Hendrix 2010) and may well be household- or even individual-specific (Dewey and Adu-Afarwuah 2008). Many key issues related to undernutrition remain uncertain or unknown: definitions of undernutrition are hard to pin down even for basic nutrients (e.g. vitamin A), the effects of shortfalls of particular nutrients are hard to predict even in controlled settings, the effects of shortfalls of collections of nutrients are essentially unknown, and the detailed nutritional status of children in developing countries is rarely known (for an exception, see Engle-Stone et al. (2012) and (Engle-Stone et al. 2015)). For these and other reasons, SQ-LNS products do not always achieve the expected results (e.g., (Maleta et al. 2015)). Although we do not address these nutrition and child development complexities in this paper, they are broadly relevant to our focus on household demand for SQ-LNS and may have implications for delivery and effective use of supplements to prevent child undernutrition.

2.2 Health Investments, Behavioral Biases and Delivery Platforms

The literature on the demand for preventative health and nutritional products in developing countries makes it clear that despite high private returns, household adoption of and willingness to pay for many preventative products is often quite low (Dupas 2011 provides an overview). The persistence of this phenomenon across many different preventative products, including insecticide-treated bednets, water filtration systems, improved cook stoves, and immunizations, has primarily been explored in the context of liquidity constraints (Beltramo et al. 2014, Meredith, et al. 2013, Tarozzi et al. 2014) and a lack of information about health risks and potential returns to prevention (Ashraf et al. 2013, Beltramo, et al. 2014, Chowdhury et al. 2011, Meredith, et al. 2013).

Even with the provision of information and/or free or highly subsidized distribution of preventative health products, adoption and use rates over the long-term often remain low (Thurber et al. 2013). Beyond information and financial constraints, there may be other household-level behavioral considerations that play an important role in a household's decision to adopt and/or regularly use a preventative health product. These include framing effects, present bias, zero price effects, social norms, and loss aversion (Buttenheim and Asch 2013, Dupas 2011). Preventative investments in products like SQ-LNS that require regular purchases and high frequency usage demand consistent decisions that are likely only to be sustained over time by the formation of habits and usage defaults that reduce the demands on limited attention and simplify compliance (Banerjee and Mullainathan 2008, Dupas et al. 2013, Mullainathan and Shafir 2013, Shah et al. 2012).

Several platforms can potentially deliver micronutrient products to vulnerable populations via interventions in agriculture, health and social-protection (Olney et al. 2012). How effective these platforms are in practice depends in part on how well they take into account the behavioral biases and constraints described above. In the health and nutrition domain, three delivery platforms stand out. First, government-supported local health clinics provide frontline medical services. Although often resource-constrained, these clinics also sometimes distribute nutritional products procured by governments or UN agencies (especially large-quantity LNS (RUTF)). Second, traditional private retailers and market vendors often sell commercially available fortified nutritional products, including infant formulas, porridge powders, biscuits and other snacks. In most developing countries, such sellers and products are generally available, even rural areas. Finally, a hybrid of public health clinics and traditional private retailers has emerged in the form of 'community health workers' who are trained to provide basic health education and incentivized as micro-entrepreneurs to sell health-related products door-to-door, and/or to respond to local demand for health services. With support from the Global Alliance for Improved Nutrition (GAIN), for example, two NGOs – BRAC and LivingGoods – have created networks of community health workers in Africa and Asia and include micronutrient powders in their menu of health products (e.g., https://livinggoods.org/what-we-do/) .

While the market trial at the center of our research design uses traditional private retailers as our delivery platform and is therefore not a direct test of demand under the other two platforms, the results of this trial shed light on household valuation of SQ-LNS and are nonetheless relevant for both health clinics and community health workers. Insights from this market trial are particularly useful because evidence on the persistence of household demand for micronutrient supplements is sparse. As far as we know, the only evidence to date on the sustainability of market-based distribution of micronutrients is provided by a study in Western Kenya that monitored the sales of a micronutrient powder over a 12-month period during a cluster-randomized trial that promoted and marketed Sprinkles® (Suchdev et al. 2010, Suchdev et al. 2012) and conducted a follow-up afterwards (Suchdev et al. 2013). Sold by established vendor groups who sell health products to members of their communities, the daily sachets were priced at approximately $0.027 as a component of an integrated health promotion and income-generating program. During the trial, randomly selected households (n=550) in 30 treatment villages and 30 control villages were visited every two weeks to monitor Sprinkles purchases and use. The biweekly purchase data suggest that, overall, nearly 93% of children in the target age range (6-59 months) consumed Sprinkles® at least once during the 12-month period, but consumption was infrequent, averaging .9 sachets per child per week in intervention villages (Suchdev, et al. 2012). Follow-up data collection activities that occurred 18 months after the end of study-related marketing and monitoring of Sprinkles purchases showed a significant decline in Sprinkles use, suggesting sustained (and potentially costly) marketing and promotional activities may be necessary for the long-term sustainability of such programs (Suchdev, et al. 2013). In contrast to this study, our research design enables us to track all purchases of SQ-LNS, by customer, for over one year and provides a more robust evidence base for evaluating demand persistence, including sensitivity to price and promotional activities, for a nutritional supplement delivered via a market platform.

2.3 iLiNS-Zinc Project in Burkina Faso

The data used in these analyses were collected in close collaboration with the iLiNS-Zinc clinical nutritional trial of SQ-LNS products (Hess, et al. 2015). The trial was conducted in 34 communities in a large corridor north of Bobo-Dioulasso in the south-western corner of Burkina Faso. Randomization was done at the community and concession (i.e., family compound) levels. First, communities were stratified by selected indicators (population size; proximity to the all-weather road and to Bobo-Dioulasso; and health district affiliation) and then randomly assigned within strata into treatment communities (25) and control communities (9).[4] Children who met the inclusion criteria in the treatment communities were then randomly allocated to one of four intervention arms for 9 months (from 9 to 18 months of age): 1) SQ-LNS without zinc and placebo tablet (LNS-Zn0); 2) SQ-LNS with 5 mg zinc and placebo tablet (LNS-Zn5); 3) SQ-LNS with 10 mg zinc and placebo tablet (LNS-Zn10); or 4) SQ-LNS without zinc and 5 mg zinc tablet (LNS-TabZn5). Children in the control communities did not receive SQ-LNS or tablets from 9 to 18 months of age, but received SQ-LNS from 18 to 27 months after the data collection was finished. Enrollment of the rolling sample continued for approximately 11 months.

A weekly ration of SQ-LNS was delivered initially to participating children in the intervention groups in plastic pots containing 140g (sufficient for one week). The child's caregiver was provided with a measuring spoon and advised to feed the day's allotment (20g = 2 spoons) in two separate servings at mealtimes. After 13 months of project implementation, the packaging changed and children received seven sachets containing 20g each per week; caregivers were instructed to feed their children one sachet/day, mixed with food at mealtime. The SQ-LNS formulas for all treatment groups were identical, except for their zinc content. Zinc tablets were water-dispersible and contained 5mg zinc or an identical placebo. The caregivers were advised to provide the tablet once daily, dissolved in water or breast milk, but not with other foods. Caregivers were given brief child feeding advice at enrollment, which included the above described instructions for SQ-LNS and tablets and the recommendation to continue breastfeeding and to provide a large variety of foods. All children in the intervention communities were provided with continual monitoring for malaria and diarrhea, and treated as needed.[5]

3 Research Design and Data

In the context of the iLiNS-Zinc project described above, we designed a series of research activities to: a) evaluate households' valuation of and demand for SQ-LNS over the short and medium term, b) from what we discovered about demand, distill the implications for public policy action regarding retail outlets as a potential delivery platform for these and similar products, and, c) via this platform, assess the potential for sharing the cost burden with consumers. We used two different approaches to assess rural households' demand for SQ-LNS. We first conducted experimental auctions with a mix of iLiNS and non-iLiNS households in our study area to elicit incentive-compatible experimental WTP in order to

[4] Treatment communities received SQ-LNS interventions at the outset of the study; control communities received SQ-LNS after the study had ended.

[5] Thus, the iLiNS-Zinc 'package' included home-delivered SQ-LNS, and continual monitoring/evaluation and treatment, as needed, for malaria and diarrhea.

provide estimates of initial demand. Using these auctions as a point of departure, we then launched a market trial in which we contracted vendors in 14 villages within our study area to maintain supplies of, to sell, and to track sales of SQ-LNS (under the local name *Fanga Dengue*) for over one year. In this paper, we focus on the market trial with local vendors, but include details about the experimental auction in Appendix A.

3.1 SQ-LNS Demand Preliminaries

When assessing demand for a new product or service, it is important to establish a common understanding of and appreciation for the relevant features of the new product or service. In the case of SQ-LNS, this raises two key questions: (1) What specifically should households know and understand about the intended usage and potential benefits of SQ-LNS in order to assess their valuation of the supplement? (2) How should this information be conveyed to rural households, especially in cases of limited caregiver or household head literacy? The broader iLiNS-Zinc project described above rigorously evaluated the impact of SQ-LNS on various growth and development outcomes of children (Hess, et al. 2015). While these results are now available as an evidence base with which to communicate the potential benefits of SQ-LNS, these results were only starting to emerge at the time of the experimental auctions and the launch of the market trial. We worked closely with our nutritionist collaborators to draft the informational scripts to be used in the auctions, and to develop packaging, placards, and other promotional materials that were used in the SQ-LNS market trial. Using language that was carefully crafted so as to not over-state what we knew about the benefits of the iLiNS-Zinc 'package' (which, once again, included an SQ-LNS product and continual screening/treatment for malaria and diarrhea), we informed caregivers of children in the target age range that: a) the average diets of children in the area are deficient in one or more of the micronutrients that nutritionists believe are important for child growth and development, and b) the SQ-LNS product described/offered to them contains all of the micronutrients that nutritionists believe are needed for children to grow and develop according to their genetic potential. Appendices A and B provide more detail about the information provided to rural households and how this information was conveyed.

As described in greater detail in Appendix A, we conducted a series of experimental auctions for SQ-LNS in each of the 14 villages in the iLiNS-Zinc study area that would be part of the market trial. The auction sessions, which were conducted in June 2013, marked the beginning of the market trial and involved fathers and mothers (N=505) of children in the target age range (6-24mo), most of whom did not previously participate in the iLiNS-Zinc trial. Auction participants were given an opportunity to purchase a week's supply of SQ-LNS for their children using a discretized Becker-DeGroot-Marschak (BDM) mechanism. Because the efficacy of SQ-LNS depends on regular consumption throughout early childhood, we asked a series of follow-up questions about WTP in the long-term. Specifically, we asked if a participant would pay her maximum WTP for SQ-LNS each week until her child was 24 months. The price was then increased or decreased in small increments until the participant changed her answer.

Data from this incentive-compatible auction provided the point of departure for the design of the market trial. Figure 1 depicts individuals' valuation for SQ-LNS as demand curves. The solid demand curve in this graph is constructed based on individuals' incentive-compatible willingness-to-pay (WTP)

for a one-week supply of SQ-LNS. The dashed demand curve is constructed based on individuals' stated WTP for SQ-LNS for consistent weekly purchases for the full 18 months of recommended usage (6-24 months of age). Although not incentive compatible, we believe this long-term WTP is useful because it was elicited immediately following the auction for a one-week supply, and is therefore anchored to the incentive-compatible initial WTP. The comparison of the two curves suggests that persistent demand for SQ-LNS is roughly 40% lower than demand for a single-week supply. For example, whereas 50% of participants were willing to pay $1 or more for a week supply, only 30% claimed to be willing to pay this amount consistently over 18 months of usage. The horizontal solid lines in the figure show the high and low market prices used in market trial. Because the trial was designed to assess demand, we only considered potential demand when setting these prices and not production costs. Indeed, even the high price was below estimated production costs of approximately US$ 0.14/day or US$ 0.98/week (Lucas et al. 2015). The horizontal dashed lines show average expenditure levels for households in the broader iLiNS-Zinc project to put these prices in perspective; the low price in the trial is roughly equivalent to the average weekly non-food cash expenditures per child on clothes, sweets, school fees, and toys. While the low price used in the market trial might be prohibitive for relatively poor households, it is on par with per child spending on snacks and sweets for many households with average and above average expenditures.

3.2 SQ-LNS Market Trial with Vendors

We designed a market trial as a rigorous retail test of private demand for SQ-LNS. This market trial was conducted in the same 14 villages that hosted experimental auctions for SQ-LNS. It was launched immediately following the experimental auctions in each village, and the nature and timing of the market trial was announced to auction participants at the conclusion of each session (e.g., "Beginning next week, you will be able to purchase SQ-LNS at Abdul's shop on the corner between the mosque and the market.")

The primary objective of this market trial was to rigorously evaluate the persistence of demand for SQ-LNS in a naturally-occurring market setting familiar to households in our study area. For this purpose, we engaged one or more local vendors[6] in each village as collaborators (32 vendors in all, 29 of whom were engaged for the full duration of the trial). We used a contract to establish the terms of the collaboration, including a small commission the vendor would receive for each sachet they sold. Along with an initial inventory of SQ-LNS, each vendor was given a placard that included information about how SQ-LNS is to be consumed and by whom, and its potential benefits. They were also given a lockbox to collect payments for the product and were told that they could only sell sachets to customers with special voucher booklets. Each sale was registered using a slip from these booklets; vendors would write the number of sachets sold and the date and put the slip into the lockbox with the cash paid by the customer. Voucher booklets were distributed to all iLiNS households and auction participants. Three

[6] We explored the option of using other outlets in addition to (or even instead of) local vendors. For example, health clinics and pharmacies might make sense as outlets for SQ-LNS. We settled on engaging only on local vendors as this would ensure the most widespread access to SQ-LNS, as every village involved in the study has at least one permanent shop, and also emphasized SQ-LNS as a preventative rather than a treatment product.

extra booklets were given to iLiNS households – booklets they were encouraged to distribute to friends. Vendors were also given booklets to keep on hand for interested customers who had not yet received a voucher booklet. Using a unique, household-specific code on each voucher booklet, we are able to track purchases over time. Once each week, members of our field research team (would-be 'sales reps') would visit each vendor, collect payments and voucher slips, reconcile the money collected and product sold, refresh the vendor's inventory, and calculate and pay the vendor his commission. Appendix B contains additional detail on how the market trial was implemented.

For improved statistical power and to improve our ability to attribute village-level demand responses to cross-village price differences, we used a 'matched pair randomized cluster' (MPRC) approach in which villages were paired based on observable demand and market characteristics before randomly assigning the low price to one village in each pair and the high price to the other. To match villages in this MPRC approach, we exploited baseline census data, market characteristics data, and detailed socio-economic data that were collected in the broader iLiNS-Zinc project. Specifically, we selected six matching variables to capture features of demand and market size that are relevant to SQ-LNS: village population, distance from village to paved road, village mean asset index, village mean food insecurity score, mean number of shops per village, and the share of households that had heard of Plumy'Nut® prior to the beginning of the project in 2009. These six matching variables were used to construct a factor analytic matching index. Finally, we paired villages with their nearest neighbor in terms of this index.[7] With the village pairs formed, a simple coin toss determined which of these villages (vendors) would sell SQ-LNS at the low price (150 CFA/seven-sachet strip; $0.30) and which would sell at the high price (300 CFA/seven-sachet strip; $0.60).[8] Figure 2 includes a map of these 14 villages that indicates the village pairings and the random price assignment.

This market trial was implemented in three separate phases. In phase one, we randomly assigned seven of the villages to a low-price treatment and the other seven to a high-price treatment. Phase one of the trial was launched in July 2013. In phase two of the trial, we reduced all high prices to 150 CFA/strip so that a single, uniform price prevailed across all 14 villages and 29 vendors. Comparing purchases in this phase with those in phase one provides a 'within-village' angle on price sensitivity of demand. It also enables us to analyze the dynamics of market demand in these villages by, among other things, contrasting responses on the intensive margin (current clients increasing purchases) and the extensive margin (new clients entering the market). Phase two the trial was launched after week 17 of the trial.

[7] To get unique pairs, we used an iterative process in consultation with our field manager. The final pairings are based on three first-order matches (nearest neighbors), one second-order match, one third-order match, and two fourth-order matches.

[8] Based on current production technologies and input prices in Niger, even this 'high' price does not cover all production costs or the likely mark-up required by vendors. Cost-cutting innovations may help to close this gap, but is unlikely to close it entirely, which underscores the need for some level of public support or subsidization to ensure sufficient consumption of SQ-LNS to generate the expected growth/development benefits, if broad-based provision/promotion of SQ-LNS products becomes part of rural nutrition/health programs in rural Burkina Faso.

Finally, in phase three of the market trial we introduced an individual-level non-price randomization. We conducted a series of promotional sessions on market day in each of the 14 villages. These sessions informed caretakers of target age children about the use, availability and potential benefits of SQ-LNS using a format common in the region. Large groups congregated around the loud speakers and project team. An entertaining member of the project team provided some basic information about the product and then led a question-answer interaction with the crowd. To ensure representation from both male and female caretakers from target households, we actively recruited parents of young children. This was followed by a popular prize wheel for participants who cared for target age children, often including two members of the same household (e.g., a mother and a father). Each person spinning the wheel had equal chances of winning a small, medium or large prize. The small prize consisted of a free strip of seven SQ-LNS sachets. The medium prize consisted of a promotional hat and t-shirt. The large prize consisted of the hat and shirt and a product loyalty card that enabled the recipient to redeem 28 empty SQ-LNS sachets for a small reward (maximum of four rewards). We took photos of the loyalty card winners so we could verify their identity at the time of redemption and gave them a sachet hook for collecting empty sachets and a menu of reward options.[9] Phase three of the trial was launched in weeks 32-34 of the trial and concluded in August 2014 (see Appendix C for additional details about these promotional sessions).

Table 2 summarizes several dimensions of the research design disaggregated by different groups of voucher booklets. The three phases of the market trial appear as blocks of rows with relevant disaggregation within each phase. By the end of the trial, over 2,600 households had acquired a voucher booklet, 80% of which were used at least once and over half of which were distributed by iLiNS participants to their friends and vendors to customers. The average number of sachets purchased per day per voucher booklet is 0.10, with some interesting variation across treatment arms of the SQ-LNS market trial. The effect of both the low price (phase one) and the loyalty card (phase three), for example, is apparent. In the analysis of the next section, we explore these patterns more rigorously.

3.3 Additional Sources of Household and Other Data

In order to characterize household demand for SQ-LNS using the market trial data described above, we need to know something about these households. We collected these data from different households at different times depending on their participation in the study. For those participating in the clinical nutritional trial of the iLiNS-Zinc study – in either a treatment or a control arm – we collected detailed socioeconomic data at the individual, household and concession levels at enrollment and again at the project endline (when enrolled children completed the treatment regime, at 18 months of age). In addition, upon enrollment, a subsample of approximately 30% of the households from each trial arm was randomly selected to participate in several in-depth socioeconomic studies. In these households, questionnaires were administered to either the male head of household or to the child's primary caregiver. For auction participants, we collected basic household and individual participant data before

[9] These options included familiar items in local shops such as small sachets of tea and laundry detergent and sugar (0.5 kg). The market value of these items was approximately 250-300CFA.

or after the auction session. These household data are less detailed than the enrolment and endline data that were collected in the context of nutritional trial, but nonetheless allow us to characterize basic demographic and economic features of these households.

The majority of the households represented in this study participated in neither the nutritional trial nor the auction. Instead, they enter our data by purchasing SQ-LNS using a voucher booklet that they received from a friend who participated in the nutritional trial, or directly from one of our vendors. In order to maintain the most natural market setting for the market trial, we opted not to contact these households for the duration of the trial. Throughout the market trial, therefore, our only link to these households was via their voucher code, which indicated their village of residence and their respective patterns of SQ-LNS purchases, but nothing more.

At the conclusion of the market trial, we randomly sampled households with voucher booklets – stratified by intensity of demand over the course of the trial – and conducted a detailed socioeconomic survey. To construct this sub-sample, we stratified households based on their SQ-LNS purchase patterns, including one strata of households with target-age children that never purchased the product (see Appendix D for details of these endline sampling procedures).

As a final data layer, we use the location of the villages in our study to merge weekly rainfall experienced during the approximately one-year market trial, by village, into the dataset. These rainfall data, described in greater detail below, are constructed as part of the Famine Early Warning Systems Network (FEWS-NET) of the U.S. Agency for International Development (USAID). Combined with the spatial and temporal variation in SQ-LNS demand, these rainfall data allow us to test for the effects of one key aspect of weather on demand, an important consideration given the heavy reliance of our study area on rainfed agricultural production.

3.4 Aggregate SQ-LNS Demand & Measures of Demand Persistence

We first provide a few graphical depictions of the evolution of SQ-LNS purchases over the course of the market trial. Figure 3 shows the evolution of aggregate demand for SQ-LNS over the course of the 62 week market trial.[10] Total sales show a steady decline over the trial and converge on about 900 sachets (128 strips) per week during the second half of the trial. The effect of lowering prices in the initial high price villages after week 17 and of the promotion and loyalty card distribution around week 33 is apparent in this figure.

To better interpret total sales by week, we normalize total sachets sold by the estimated number of target age children in the 14 villages included in the trial.[11] This measure of demand – which provides a rough proxy for 'community compliance' – indicates the average number of SQ-LNS sachets purchased

[10] We observe the date of all purchases. Because most of these purchases involve seven sachet strips (see Figure S1), we aggregate purchases into weekly time steps.

[11] Estimates of the sizes of the target population were based on local census data collected in 2013 by the Centre médicale de Dandé (CMA), Burkina Faso.

in a community for each target child in the community. The benchmark based on the iLiNS-Zinc nutrition trial protocol is one sachet per child per day. This measure is obviously crude because we do not directly observe consumption by children and overstates actual compliance if SQ-LNS is shared among non-target household members, but it provides an indication of the coverage of retail distribution. Table 3 reports the number of target-age children in each village as well as the overall compliance rate (total sachets sold per day / target-age child) for each village in our sample. The overall compliance rate is under 5%, which suggests that 95% of the need implied by full compliance is unmet by the market trial. This table also reports the 'coverage rate' computed as the number of voucher booklets per target-age child. In most villages, there was well over 50% coverage by the end of the trial, but many of these voucher booklets were never used. When we include only 'active' vouchers in this calculation, we have an overall coverage rate of 61%. Taken together with the compliance rate, this suggests that much of gap between recommended and actual SQ-LNS consumption is due to infrequent or inconsistent purchases by target households with voucher booklets in hand.

Figure 4 shows the evolution of the average three-week community compliance rate for low and high price villages, computed as a weighted-average of the community compliance rate for each village in the low- and high-price groups, respectively. The effect of the initial high price on compliance is clear in this figure, as is the response to the price drop that marked the beginning of phase two. Intriguingly, the response to the promotional activities at the beginning of phase three appears to be isolated to villages with initial high prices.

Using the unique voucher codes, we can track purchases of individual households. A few summary statistics from these voucher-level data will help to set the stage for deeper analysis presented below. Since it is formulated as a daily supplement, one of the crucial demand aspects for SQ-LNS is the consistency of demand over time, which we refer to as demand persistence. There are several potential ways to measure demand persistence. We choose to measure it using a three-week moving average of the number of sachets purchased per day.[12] As an initial depiction of this measure of demand persistence, Figure 5 shows the cumulative distribution function of this average for phase one of the trial. While price appears to have a significant effect on demand persistence, most households with access to SQ-LNS at the low price still consume well below per-protocol levels. Specifically, while less than 5% of households facing the high price purchase at least one sachet a day, roughly 20% of households in low price villages purchase this much over the course of phase one of the market trial.

4 Analysis and Results

The research design and data described above open several potential perspectives on SQ-LNS demand and demand persistence, and hence on the potential for market-based distribution platforms to contribute to addressing undernutrition problems and to public-private sharing of the cost burden of

[12] For an alternative measure, see Figure S2, which is based on the number of weeks a given household purchases at least 7 sachets (i.e., the number of weeks at full compliance). We prefer the three-week moving average as a continuous measure.

supplementary foods. We begin by estimating the price elasticity of demand using weekly sales by village and the random assignment to low and high initial prices in the market trial. We account for the MPCR structure of the research design and separately estimate the elasticity for initial and repeat purchases in order to shed light on the price sensitivity of one measure of demand persistence. The bulk of this section contains voucher-level analyses that push beyond weekly sales by village and allow us to treat households as the unit of analysis. These voucher-level analyses require careful treatment of non-purchases, which we discuss in detail. We then proceed with analyses of demand persistence, loyalty card effects, seasonality effects, and the impact of household characteristics on SQ-LNS demand.

4.1 Estimation of Price Elasticity of Demand for SQ-LNS in Market Trial

In this sub-section, we exploit two parts of the market trial to estimate the price elasticity of demand for SQ-LNS: the stage-one MPCR-based low-high price treatment and the price drop after week 17 that marked the transition to stage two of the trial. In the first case, we estimate (arc) elasticities directly using total sales by village. Since the low price (150 CFA/strip) is 50% lower than the high price (300 CFA/strip), we can directly compute an arc elasticity of demand for SQ-LNS based on the percent change in demand in low price villages relative to high price villages. We normalize total SQ-LNS demand by the size of the target population, which we estimate as the number of children under age 2 in each village. Specifically, if we denote the total number of sachets sold in low and high price villages, respectively, as $Q_L = \sum_h q_{Lh}$ and $Q_H = \sum_h q_{Hh}$, where *h* indexes households, and their respective target populations as N_L and N_H, then a raw arc elasticity of demand is given by:

$$\eta_{Raw} = \left| \frac{\left(Q_L/N_L - Q_H/N_H\right)/\left(Q_H/N_H\right)}{-50\%} \right| = 2\left(Q_L/N_L - Q_H/N_H\right)/\left(Q_H/N_H\right) \quad (1)$$

Note that since we normalize by target population size, this elasticity indicates the price sensitivity of demand for SQ-LNS in terms of sachets per target child.

In order to reflect the MPCR structure of the market trial, we devise a pairwise-corrected arc elasticity of demand based on the MPCR population estimator proposed by Imai et al. (Imai et al. 2009). This pairwise-corrected elasticity, essentially a weighted average of the pairwise arc elasticities of demand, is as follows

$$\eta = \sum_{k=1}^{7} \frac{\left(N_{Lk} + N_{Hk}\right)}{N} \frac{2\left(Q_{Lk}/N_{Lk} - Q_{Hk}/N_{Hk}\right)}{Q_{Hk}/N_{Hk}} \quad (2)$$

where subscript *k* denotes the matched village pairs and subscripts *L* and *H* indicate the random assignment of the villages in each pair to low and high price, respectively.

Note that although villages were assigned to treatment, in a few cases households traveled to neighboring villages to take advantage of lower prices. Our vouchers enable us to pinpoint such 'displaced' sales and suggest that they are relatively rare, occur predominantly between two specific high-price villages and two low-price villages, and were virtually non-existent until the second month of the trial. As a correction for these displaced sales, which would artificially inflate our arc elasticity

measures, we attribute sales to the home villages of the buyers. This as a conservative correction for displaced sales because it implicitly assumes that households would have purchased SQ-LNS at the high price in their home village if it had not been available in another village at the low price.[13] We prefer to be conservative in this case because our vouchers do not enable us to test for missing purchases from households that simply choose not to purchase SQ-LNS once they learned of a lower price in another village. While we are confident based on reports from our market agents that such missing purchases are rare, we prefer to be conservative at this stage.

Since these arc elasticity measures are not estimates with standard errors, we use bootstrapped samples to generate standard errors.[14] We report these arc elasticity measures and their 95% confidence intervals in Table 4. In addition to the pairwise-corrected arc elasticities computed according to equation (2), we report the raw overall arc elasticity using six weeks of purchases before and after the price decrease in the initial high price villages. Demand for SQ-LNS is extremely price sensitive. This is particularly true for repeated purchases, which is especially troubling since the intended benefits of SQ-LNS hinge on consistent consumption over many months. For comparison, prior estimates of the arc price elasticity of healthcare demand in rural Burkina Faso are -0.8 overall and -3.64 for children under age one (Sauerborn et al. 1994). This prior estimate for children is similar to our point estimate for first purchases, which seems sensible as most visits to local health clinics for medical attention are one-off visits that are much more like first purchases in our context. In sharp contrast, repeat purchases impose a recurring cost that is very different qualitatively. This comparison suggests that while prior estimates of healthcare demand elasticities may therefore give some guidance to the price sensitivity of demand for therapeutic healthcare, they are not very useful for characterizing demand for preventative healthcare such as nutritional supplementation, which requires repeat purchases.

4.2 Voucher-Level Analyses: Target Households & Non-Purchases

To leverage the richness of our voucher-level data, we must account carefully for non-purchases. To appreciate this issue and the assumptions in play, consider three types of household in our data. The first household type received a voucher booklet directly from our research team after being screened as having target-age children in either the auction or the promotional activities that mark the start of phase three. Such a household clearly qualifies as a 'target household' at the time of the screening. When the member of this household purchases SQ-LNS, the household's voucher number allows us to track this purchase. When the household chooses not to purchase SQ-LNS in a given week, we can infer this non-purchase is a zero purchase. After many weeks of non-purchases, however, we become less certain about how to treat non-purchases. All the information we conveyed to vendors and households emphasized that the target age window for children was 6-24 months. It is therefore possible that this household that is clearly in the target in the beginning ultimately 'ages out' of the target, in which case

[13] As another correction for displaced sales, we can restrict the analysis to the first four weeks of the trial. This yields estimates that are comparable, but less precise because of the smaller sample.

[14] In creating these bootstrapped samples, we assume each purchase transaction is independent. We do not cluster these bootstrap samples by household in order to avoid over-weighting initial purchases relative to repeat purchases.

recording non-purchases as zeros may downwardly-bias estimated demand among the target population.

The second household type also received a voucher book from our research team after being screened as a target household, but never purchased SQ-LNS after receiving their voucher booklet. While the initial non-purchases may really indicate zero demand from a target household, our confidence in this inference ultimately fades. Moreover, our confidence that non-purchases are true zeros (purchases that should have taken place, but did not) fades more quickly for this household than for the first household type because the lack of a track-record of purchases suggests the possibility that the household was screened into the target by mistake. In short, non-purchases by this second household type may indicate zero demand for SQ-LNS, but may also be due to 'aging out' (as before) or screening errors.

The third household type receives a voucher booklet directly from a vendor at the time of first purchase. Unlike the first and second household types, we have no initial screening to ensure this is a target household.[15] For this household type, then, we must rely entirely on the pattern of its observed purchases and non-purchases to infer whether it is truly a household in which a child of target age resides. For example, a one-off purchase without any repeat purchases may indicate that the household does not really have a target-age child, whereas sustained purchases over a few weeks may be strong evidence of a target-age child in the household.

As these three household types illustrate, we have two sources of information for inferring whether a given household has a target-age child or not: (i) our own screening procedures for the subset of households that received the voucher booklet directly from our research team and (ii) the purchase patterns of households.[16] This inference matters because it determines whether we treat a non-purchase as a zero purchase or as a missing value, which is a consideration for any voucher-level analysis. In contrast, the community compliance rates discussed above and presented in Figure 4 use village census data on the age distribution of children to determine the number of target-age children. These community compliance rates are therefore the most conservative estimates of 'coverage' by our market trial.

In order to proceed with voucher-level analyses, we formulate two inference approaches, one inclusive and the other more exclusive (i.e., restrictive). The inclusive approach conservatively assumes that all households that received their voucher booklets after being screened by the research team have at least one target-aged child throughout the market trial period. Among households that received their voucher booklets from a vendor, we assume that any household that makes more than one SQ-LNS

[15] We instructed vendors to share basic information about the proper usage and intended benefits of SQ-LNS to such customers, but have only indirect control over this information. In contrast, our research team had direct control over screening households in the auction and promotional activities (the first and second household types).
[16] As described above, we have some detailed data for a sub-set of households, including some household demographic data. Unfortunately, we do not have sufficient resolution on the age of target-age children to precisely determine when households 'age out'.

purchase similarly has a target-aged child from the week of their first purchase until the end of the market trial. This inclusive approach results in a majority of non-purchases being registered as zero purchases for the entire market trial period.

The second, more exclusive approach imposes a series of criteria to infer whether a household likely has a child in the target age range. We use each household's pattern of SQ-LNS purchases to estimate the likelihood that the household has a child in the target age range and drop households when the likelihood of having a child in the target age range falls below 20%.[17] This approach is only viable for households with a purchase history. Households that received their voucher booklet in the auction or the promotional activity and that never made a purchase are dropped from the analysis after five weeks of non-purchase.

In the voucher-level analyses that follow, we use these two approaches as upper and lower bounds when assessing demand persistence. While the inclusive approach may downwardly-bias demand persistence, the exclusive approach may do the opposite. It is worth underscoring as well that these approaches obviously only apply to our voucher data; given that 'voucher coverage rates' are less than 100%, there are households with target-age children who never end up with a voucher booklet at all. As a comparison of these two approaches, Figure 6 shows a side-by-side progression of weekly demand persistence across the trial for low and high price villages by each approach. In the third phase of the trial, the exclusive approach to dealing with non-purchases leads to average demand that is roughly three times higher than the much more conservative inclusive approach.

4.3 Transaction-Level Price Sensitivity of SQ-LNS Demand

Once we have assumptions in place for dealing with non-purchases, we can estimate transaction-level models. We begin with a graphical comparison of the low and high price villages in phase one based on this simple specification:

$$D_{ijt} = \alpha_0 + \boldsymbol{\alpha}(lowprice_j \#\# i.week_t) + \phi_j + \varepsilon \quad (3)$$

where D_{ijt} indicates demand for SQ-LNS measured as three week moving average number of sachets purchased per day for household *i* in village *j* and week *t*, δ_i is a voucher source fixed effect, ϕ_j is a village pair fixed effect to account for the MPCR design of the randomized low and high price villages, and the disturbance term is clustered by village-month to allow for spatiotemporal correlations in the error. We use this specification to graph the MPCR-corrected average demand across weeks for phase one in low and high price villages in the left panel of Figure 7. This measure of persistent demand is roughly twice as high in low price villages as in high price villages. These differences are significantly different across the entire phase, but after two months demand drops to 0.2 sachets per day on average

[17] As outcome variable, this model uses a dummy variable that is one if the household's three-week moving average of SQ-LNS purchases is greater than zero in a given week and uses as four explanatory variables: (i) the cumulative total sachets purchased up to a given week, (ii) the total sachets yet to be purchased in future weeks, (iii) the number of weeks since last purchase, and (iv) voucher fixed effects. We estimate this as a linear probability model and adjust the predicted probabilities to be in the [0,1] range to facilitate the use of the criterion cutoff.

even for households in low-price villages. The change in persistent demand induced by the price drop after week 17 in initially high price villages is evident in the right panel of this figure. We distinguish between existing and new buyers in these (HL) villages in order to differentiate between intensive and extensive demand changes, respectively. While both types of demand changes are evident in this panel and ultimately result in statistically indistinguishable differences between HL and LL villages, new buyers drawn in on this extensive margin have higher demand for SQ-LNS for two months after this price drop. This price change was not accompanied by any promotional activities to advertise the new lower price for SQ-LNS, suggesting that these new buyers learned by word-of-mouth or directly from the vendors that the price had been reduced 50%.

Next, we estimate a slightly expanded specification that includes buyer random effects model

$$D_{ijt} = \alpha_0 + \boldsymbol{\alpha}(lowprice_j \#\# i.week_t) + \delta_i + \phi_j + (\upsilon_i + \varepsilon) \quad (4)$$

where υ_i is a buyer (household) random effect. Table 5 shows the results of this estimation for the two different approaches to dealing with non-purchases described above. There are some significant differences in demand by voucher source. Relative to the omitted category (Auction), households that received their voucher booklets as iLiNS participants, *from* iLiNS participants as friends, or directly from vendors have higher demand persistence. Interestingly, iLiNS participants who participated in the auction appear to have lower demand than their counterparts who did not participate in the auction.

4.4 Voucher-Level Loyalty Card Effects on SQ-LNS Demand

Next, we analyze the effects of the non-price promotion introduced in phase three of the market trial. We are particularly interested in the effect the loyalty card has on purchases. As a secondary objective, we are also interested in testing whether intra-household dynamics shape this effect. Regression analysis of our experimental auction data suggested men have a substantially higher long-term WTP for SQ-LNS than women (see Table A2). Further, during the first phase of the trial, several of our vendors shared similar perceptions about what is different about households that regularly purchases SQ-LNS. The most common perceived similarity involved the engagement and commitment of the father of the target child[18] as a necessary condition for persistent demand: Only households in which the father was committed to the care of his children and saw SQ-LNS as a potentially valuable product regularly purchased the product. The design of the promotional activities enables us to test whether the participation of the father in the promotional sessions affects subsequent demand persistence. We can specifically test whether loyalty cards won by fathers have a different effect than those won by mothers.[19]

[18] We use the term 'father' for simplicity. While most of the male caretakers in our sample – indeed in the region – are fathers, there are some uncles, brothers and grandfathers acting as caretakers as well.

[19] A more direct test of the role that fathers play in the persistence of a household's demand for SQ-LNS would be focus on the sub-sample of auction participants who attended as a mother-father couple and test whether the father's WTP in the auction has a bigger influence on subsequent demand in the market trial than the mother's

We test the impact of the promotional activities and the randomized rewards, especially the loyalty card, using the following specification:

$$D_{ijt} = \lambda_0 + \boldsymbol{\beta}(card_i \#\# i.postpromo\_period) + \lambda_1 shirt_i + \lambda_2 male\_card_i + \lambda_3 male\_shirt_i + \lambda_4 two\_participants_i + \lambda_5 male\_participant + \gamma_t + \theta_j + (\upsilon_i + \varepsilon) \quad (5)$$

where D_{ijt} indicates demand for SQ-LNS measured as three week moving average number of sachets purchased per day for household *i* in village *j* and week *t*, *card* is a dummy variable that indicates whether the household won a loyalty card during the promotional session, *postpromo_period* is a categorical variable indicating four week periods after the promotion, *shirt* indicates whether someone in the household won the second prize shirt, *male_card* (*_shirt*) indicates whether a male member of the household won a loyalty card (shirt), *two_participants* indicates whether the household had more than one participant at the session, *male_participant* indicates whether a male member of the household participated, γ_t is a week fixed effect, θ_j is a village fixed effect, and υ_i is a buyer (household) random effect. Again, we cluster standard errors in this specification by village-month.

Table 6 displays the results of this regression for all households that participated in the promotion as well as for new buyers (i.e., households that had not purchased SQ-LNS prior to the promotional sessions). In the final column, we report pre-post estimates based on the before and after purchases of preexisting buyers who attended the promotion, which includes purchases in both phase two and three. The effect of the loyalty card on demand persistence is large relative to baseline demand and statistically significant. Specifically, possession of a loyalty card more than doubles a household's demand for SQ-LNS, from 0.16 sachets to 0.34 sachets per week. The point estimates for interactions with subsequent post-promotion periods are all negative, statistically significant, and increasing in magnitude, suggesting that the effect of the loyalty card fades over time. The loyalty card effects for existing buyers (column 3) are statistically more persistent than for new buyers, which may reflect time invariant differences between these types of buyers (i.e., existing buyers self-selected prior to the promotion) or path dependency in purchase patterns. The final two columns of this table show that the loyalty card effects are initially stronger but less persistent for households with high pre-promo demand for SQ-LNS. To put the persistence of these loyalty card effects in context, the card enabled a buyer to redeem 28 empty sachets for a reward up to four times. If we observed when a loyalty card holder exhausted these four reward redemptions, we could directly test for habit formation, but without this information we can only extract weak evidence of habit formation from Table 6: the loyalty card effect seems to persist partially beyond the expiration of rewards.

WTP. While this yields a sub-sample that is too small to provide much statistical power, we do find that the father's WTP is a stronger predictor of subsequent SQ-LNS demand than the mother's WTP.

The loyalty card effects on demand are similar for existing buyers as for new buyers, but the effects over subsequent periods are estimated less precisely, which may suggest a more heterogeneous effect of the loyalty card among existing buyers.[20] Finally, there is little evidence that who in the household wins the card (or shirt, for that matter) shapes subsequent demand.[21] While this does not necessarily contradict the anecdotal evidence that the engagement of men is critical to demand persistence, it does suggest that a loyalty card does not increase men's commitment to SQ-LNS.

Figure 8 displays the conditional demand for SQ-LNS for different four-week post-promotion periods using an analogous specification as equation (3), but without pair fixed effects. The effect of the loyalty card is clear in this figure, although the level of demand even with a loyalty card is still quite low relative to the approximate full compliance rate of 1.0. Figure 9 displays average demand for phases one and three to facilitate comparison of the price and non-price impacts on demand. While the low price and the loyalty card (taking into account the value of the rewards offered) both effectively reduced price by 50%, the loyalty card offered an *ex post* reward after four weeks of consistent purchases instead of the contemporaneous price discount relative to the initial high price offered in high price villages.[22] That is, whereas low price villages faced a 50% price reduction, loyalty cardholders enjoyed a roughly equivalent price reduction based on the value of the loyalty rewards offered to cardholders. Although the randomization does not allow for a rigorous comparison of the respective demand effects of these two reductions, the pattern in Figure 9 suggests that the effects are roughly comparable in magnitude. Based on the point estimates and some assumptions that extend the low-high price demand differential into phase three, there appears to be a non-price component to the demand effect of the loyalty card above-and-beyond the value of the in-kind reward it offers, but we lack the statistical power for any strong inferences in this regard.

4.5 Voucher-Level Analysis of Seasonality of SQ-LNS Demand Persistence

SQ-LNS is designed to be consumed every day in order to meet shortfalls in micronutrient intake. For vulnerable households that experience seasonal fluctuations in food availability and/or household income, these shortfalls may be particularly acute at specific points during the agricultural cycle. Many households in our study area depend on rainfed agricultural as their primary source of income, and therefore seasonal variation in rainfall raises a particularly important dimension to household demand persistence for SQ-LNS in our sample. This raises a particularly important dimension to household demand persistence for SQ-LNS. How much do agricultural production cycles and seasonal rainfall fluctuations shape demand for SQ-LNS in this context?

[20] Although we hesitate to make too much of these differences, this pattern is consistent with a selection story in which existing buyers – who demonstrated greater interest in SQ-LNS even before the promotional sessions – are more responsive to the loyalty card over time than new buyers – who had not selected into the SQ-LNS market prior to the promotional campaign.

[21] When we restrict this estimation to couples that attended the promotional sessions, which reduces the sample dramatically, we actually find that when a man wins either the loyalty card or the shirt subsequent demand significantly falls by 0.15, which offsets any increase in demand when a woman wins the card (unreported results).

[22] At the time phase three was implemented, the four rewards had a market value of 42% (soap and tea), 50% (sugar) and 66% (bowl) of the 600 CFA required to purchase four weeks of SQ-LNS at the price of 150CFA/strip.

This question raises several potentially important considerations. Liquidity constraints, which fluctuate predictably according to the agricultural calendar and unpredictably according to production or market shocks, may hamper demand in lean seasons and may increase demand when good rainfall improves a household's expected harvest. The production calendar also dictates investment of time, attention, and both purchased and non-purchased inputs. These seasonal investments may directly compete with SQ-LNS for scare household resources. To the extent that key production times are associated with the timing of rainfall, rainfall may drive much of this competition for resources. Finally, households may consider SQ-LNS to be particularly valuable during the lean season when diet diversity is low or even in anticipation of a harder-than-usual lean season.[23]

In rural Burkina Faso, these seasonality effects have important health and nutrition consequences for children: During the lean season that accompanies later stages of agricultural production, children are both more vulnerable to disease (due to both less food availability and diseases like malaria that are more prevalent during and immediately after the rainy season) and less likely to receive healthcare attention at rural health clinics because of the high opportunity cost of time and resources during that time (Sauerborn et al. 1996). Phase one and much of phase three in our research design happen to coincide with the lean seasons of 2013 and 2014, respectively, which provides an opportunity to analyze how sensitive household demand for SQ-LNS is to rainfall during this particularly critical time of the year for child health and nutrition. While conducting explicit tests of these different potential pathways that link local rainfall to SQ-LNS demand persistence is beyond the scope of this analysis (and, indeed, our data), we can nonetheless provide some initial evidence of how rainfall fluctuations shape demand persistence.

To give some initial evidence in this regard, we collected rainfall data for our villages from the ARC2 dataset developed by the National Oceanic and Atmospheric Administration (NOAA) for programs of the U.S. Agency for International Development (USAID)/Famine Early Warning Systems Network (FEWS-NET). The ARC2 dataset is derived from four sources: infrared satellite data to estimate cloud-top temperatures, ground-based rain gauge observations, and microwave SSM/I and AMSU-B satellite data. ARC2 offers the advantage of a very high spatial (0.1 deg x 0.1 deg) and temporal (daily) resolution, and is updated on a continuous basis. Validation of ARC2 with independent gauge data showed bias in certain regions and seasons, but an error rate that is comparable to other techniques (Novella and Thiaw 2013). We use these rainfall data to construct z-scores of weekly cumulative rainfall by village compared to long-run average rainfall for that week and village (see Figure A4). Table 7 reports the results of a four demand regressions, two each for phase one (late production season until harvest) and phase three (planting through late production season), estimated using equation (6) below.

[23] Indeed, in some settings Doctors Without Borders has distributed SQ-LNS exclusively during lean seasons to prevent undernutrition – a form of temporal targeting.

$$D_{ijt} = \lambda_0 + \boldsymbol{\beta}_1(z\_rain_{jt} \#\# i.ag\_period_t) + \boldsymbol{\beta}_2(z\_rain_{jt} \#\# T_{ij}) + \lambda_1 week_t + \lambda_1 week_t^2 + \theta_j + (\upsilon_i + \varepsilon) \quad (6)$$

This specification includes cumulative rainfall as both a stand-alone variable and interacted with low price village and loyalty card for phase one and three, respectively, as well as with different production periods within each of these phases. We find a strong, positive effect of cumulative rainfall on SQ-LNS demand during the late production stage covered by phase one. Based on the estimated coefficient on the interaction of rainfall and the low price village dummy, demand is only sensitive to rainfall fluctuations in high price villages, suggesting that at the higher price, households compensate for these fluctuations by reducing their SQ-LNS purchases. In phase three, we find mixed and weaker evidence of rainfall effects on demand. While we find that the loyalty card may reduce households' demand sensitivity to rainfall, this effect is small relative to the offsetting effect of the low price in phase one and statistically weaker. Differences between these phase one and phase three results may reflect the fact that rainfall has different implications in early versus late production periods (i.e., these phases only overlap in July and August), but more likely derive from important differences between these two rainfall years. As evident in Figure S3, whereas 2013 (phase one) was a relatively dry year with all villages receiving below average rainfall, 2014 (phase three) was a relatively wet year with all villages receiving above average rainfall. As before, substantive differences between phases one and three and the sequencing of these phases make it difficult to directly compare the phase one and phase three results.

4.6 Voucher-Level Analysis of Household Characteristics and SQ-LNS Demand

Data collected in the endline survey enables us to test the relationship between household characteristics and SQ-LNS purchase patterns – albeit only for a subsample of voucher holders. We construct several summary measures of purchase intensity for each household in this subsample to regress on several observable characteristics. The first three measures from Table 8 indicate increasing demand persistence, including relative to a threshold of 0.3 sachets/day. The final measure - an indicator variable if the household purchased seven sachets or less during the time they had a voucher booklet (30% of the endline subsample) - is decreasing in demand persistence:. We find that household assets – a proxy for wealth – are strongly related to SQ-LNS demand, with relatively richer households purchasing SQ-LNS more consistently. We also find that households that purchase more than half of the food they consume have higher demand persistence. As a test of whether father involvement influences demand persistence as reported by many vendors, we construct a factor analytic index based on father involvement in SQ-LNS purchase and medical expense decisions.[24] We find that higher father involvement increases a household's demand persistence, although these estimates are mostly imprecise. In the final column, households that purchased seven sachets or less are not necessarily poorer or richer than the others. Instead, they tend to be more food secure (negative coefficient on

[24] This index is constructed based on responses to endline survey questions about who pays for SQ-LNS, who purchases from the vendor, who decides how much SQ-LNS to purchase, and general medical questions about who pays and makes decisions about medical treatment of children in the household.

hunger score) and have less involved fathers, although this latter coefficient is not significant at conventional levels (p-value=0.15).

5 Conclusions

Reducing undernutrition, especially among young children, is the focus of much international research attention and policy action. Given the breadth of micronutrient deficiencies faced by these children and diets that are characterized by limited nutrient-rich fruits and vegetables, the general absence of animal products and period food shortages, researchers and policy-makers alike have looked beyond locally available foods to address undernutrition problems. The unprecedented success of Plumpy'Nut® as a *treatment* for severe acute malnutrition among young children has sparked efforts to develop 'small-quantity' lipid-based products (SQ-LNS) designed exclusively to prevent undernutrition.

While SQ-LNS products have proved to be promising in our study area, the move from therapeutic to preventative formulations raises several distribution and delivery issues. Using SQ-LNS products to prevent undernutrition or 'hidden hunger' suggests broad-based distribution programs will be required for extended periods of time. Such procurement and distribution costs could be prohibitively high for ministries of health in many developing countries and international agencies focused primarily on treating rather than preventing malnutrition. Some combination of four distinct remedies might render SQ-LNS more cost effective and help resolve this issue: a) reduce the dosage or frequency of the recommended regimen; b) reduce production costs; c) target delivery to households with children most at risk of undernutrition; and d) leverage private demand by charging fees at distribution clinics or by selling SQ-LNS products in retail outlets. This paper aims to shed light on this final potential remedy by addressing the question, will household demand for SQ-LNS distributed through familiar retail outlets at subsidized prices be sufficient to generate the benefits observed in efficacy trials?

The market trial we study sold over 70,000 SQ-LNS sachets during a 62 week period. When compared to the number of target-age children in this study area, this level of sales falls well short of the recommended supplementation regimen. Specifically, this level of aggregate sales would satisfy the recommended 'one sachet per child per day' for roughly 5% of target-age children. While very few households stuck to this regimen, over 60% of the households to which these children belong purchased at least some SQ-LNS. This household demand is very sensitive to price. Crucially, the demand for repeat purchases is especially price elastic. We find evidence that several non-price factors similarly shape demand. Promotional activities at the beginning of phase three of the trial revived demand. In particular, a simple loyalty card more than doubled household SQ-LNS purchases, but to levels of supplementation that fall far short of the recommended regimen. While a sustained promotional campaign might lead to higher demand persistence, our research design does not allow us to test such a campaign, which would be quite costly.

Even in situations in which SQ-LNS products have been demonstrated to be efficacious in promoting child growth and development, and hence may be *socially* cost-effective as a nutritional investment, *private* demand will likely cover only a small part of the production and distribution costs, and consumption levels guided only by consumer choices in response to market signals will not likely meet

children's nutritional needs. While other delivery platforms are worth testing, the low persistent demand for SQ-LNS we find in this study may imply that many caregivers will be unlikely procure these products even if they are provided for free at health clinics or other distribution outlets.

Viewed through an economics lens, these results are not surprising. As credence goods, the benefits of consuming SQ-LNS products are not visible to caregivers over reasonable time horizons. Combined with the limited means of many households in rural Burkina Faso, it may therefore be unrealistic to expect strict compliance with the daily supplementation regimen. Viewed through a nutritional lens, these results are disappointing because they suggest that these otherwise promising products will require sustained public sector support and may therefore raise difficult tradeoffs with other public investments in health. The fact that SQ-LNS product do not appear to be efficacious in all settings due to differences in disease pressures, gut infections, and other environmental factors that influence the bioavailability of SQ-LNS introduces uncertainty at the population and household levels regarding expected growth and developmental benefits. This nutritional complexity also colors these results and raises a potentially important distinction between nutritional efficacy and the cost-effectiveness of different delivery platforms, both of which may hinge on features of the local context.

How might one resolve this impasse between demonstrated efficacy and fundamental delivery dilemmas? As suggested above, several options are worth considering. First, it may be possible to reduce the dosage of SQ-LNS that young children are recommended to receive; given the high proportion of product and production transportation costs in total costs, doing so would substantially reduce the overall cost of providing SQ-LNS. However, very little is known about the effects on child growth or development of reducing dosages below those used in field-based nutrition trials. Second, per-sachet costs could be reduced. This could be achieved by dramatically increasing the scale of production of SQ-LNS; perennial issues related to product safety might also be more efficiently addressed at larger scale. Achieving such scale economies would almost certainly lead to dramatic changes in existing, or planned, supply chains for SQ-LNS products; small countries, in particular, may be hard-pressed to cost-effectively respond to pressures to establish and maintain national SQ-LNS production capacity. Third, it may be possible to target geographic areas (though probably not households within geographic areas) and/or seasons for SQ-LNS distribution; information on dietary intake of children could be used to guide such targeting efforts. Finally, one might also identify hybrid private-public delivery strategies, perhaps linking these to cost-sharing mechanisms. For example, community-based healthcare personnel could maintain stocks of SQ-LNS products to be distributed to target-aged children, and a small fee could be collected from caregivers.

If SQ-LNS products are to reach children in need in resource-poor settings such as the one studied here, the public sector clearly has a role to play in providing the investments, infrastructure and legal frameworks required to enable the private sector (within and outside the country) to engage more intensively in these markets. While direct subsidization – a prototypical feature of public-private models – may play an important role, the public sector can also help reduce production costs by reducing trade barriers and tariffs for key production inputs. Public-sector procurers of SQ-LNS products also have a fundamental role to play in reducing the uncertainty associated with demand for these products –

credible, long-term contracts will be required to stimulate private sector investments. Private firms in the food and beverage sector, and other low margin-high volume consumer goods, have proven to be remarkably nimble and innovative in rural African settings. Focusing some of this supply chain expertise to bear on SQ-LNS markets could bring crucial innovations in production processes, and in distribution and marketing. But fully tapping this expertise will require the current public and private stakeholders in childhood nutrition to embrace this as an opportunity, to build partnerships based on trust, and to ensure that associated regulatory systems function effectively and efficiently.

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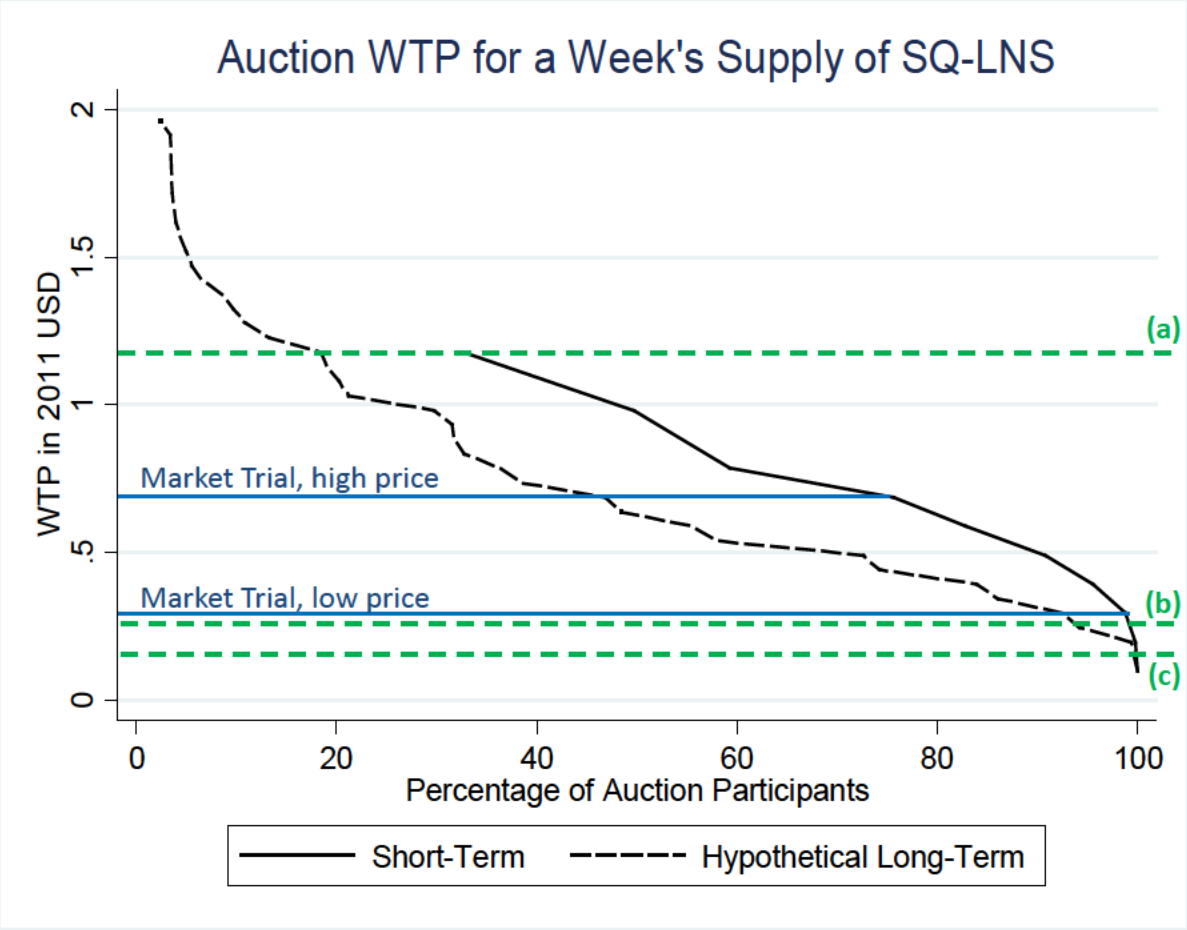


Figure 1 Demand curves for SQ-LNS based on participants' WTP in experimental auction for a week's supply and on their (anchored) follow-up hypothetical long-term WTP. Short-term WTP is truncated at approximately $1.20, the maximum price on the price list used in the auctions. The high and low price levels for the market trial are indicated with solid horizontal lines. Dashed lines reflect average household expenses from iLiNS baseline surveys: (a) average weekly cash expenditures on food per capita, (b) average weekly non-food cash expenditures on children per child under age 11 (clothes, sweets and snacks, school fees, toys, etc.), and (c) average weekly expenditures on cell phone recharges per capita.

Figure 2 Map of villages in northwest Burkina Faso (north of Bobo-Dioulasso) included in SQ-LNS auction and market trial. Color of village dots indicates village pairs matched on relevant demand and market observables. Letters denote random high (H) and low (L) price assignment within pairs used during phase one of the market trial. At the conclusion of phase one (after week 17), SQ-LNS was priced in all markets at the low price.

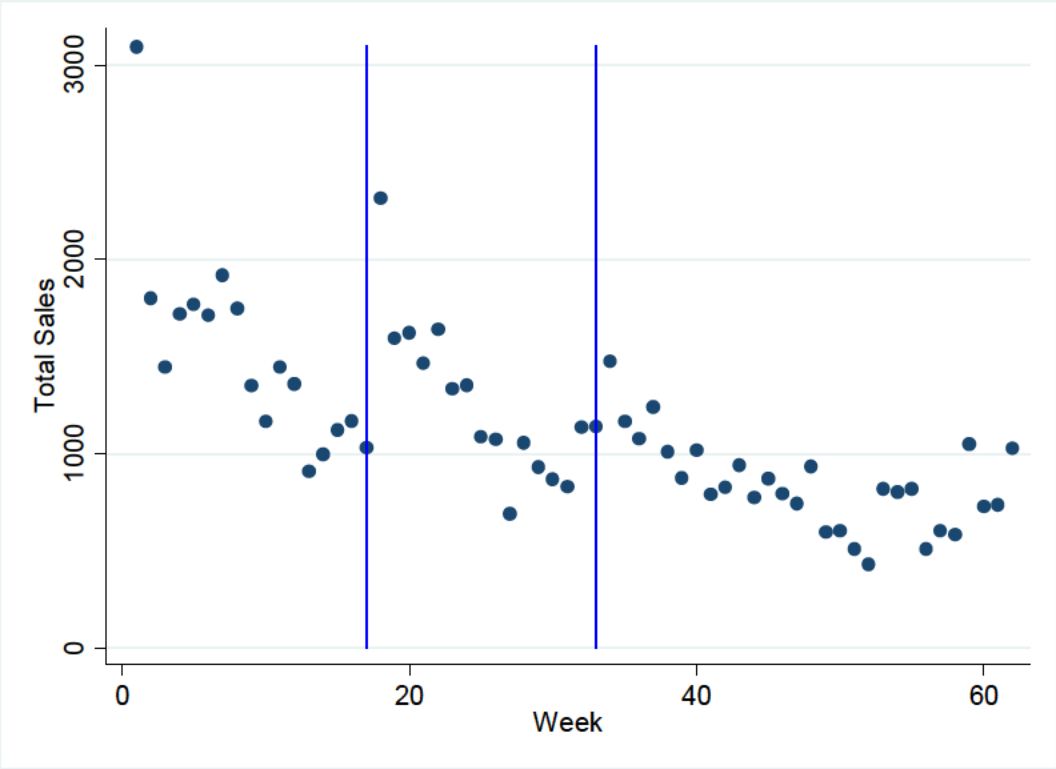


Figure 3 Total sachets of SQ-LNS sold in 14 market trial villages by week with vertical lines marking the transition from phase one (high-low prices by village) to phase two (uniform low price) to phase three (promotion and loyalty card).

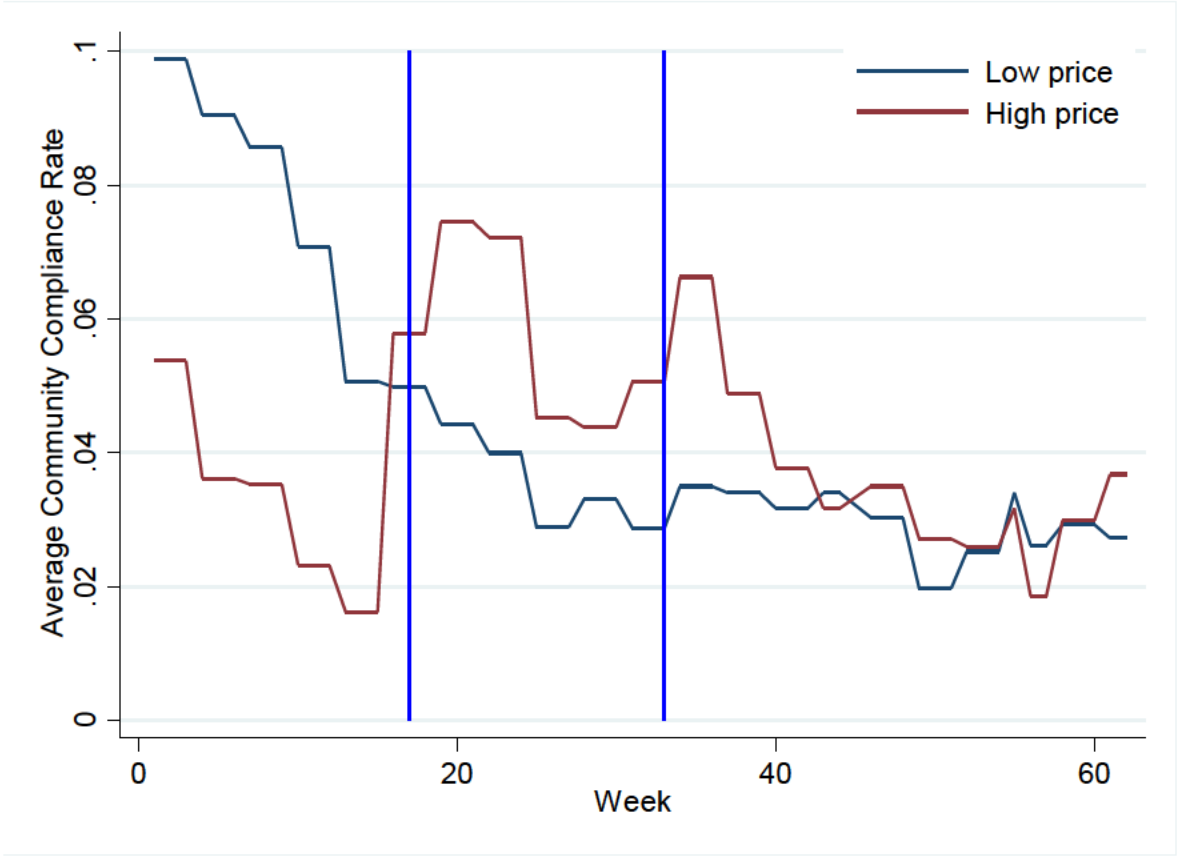


Figure 4 Three week average community compliance rate by week for villages with initial high and low prices (community compliance rate computed as (total sachets sold per day / target-age children))

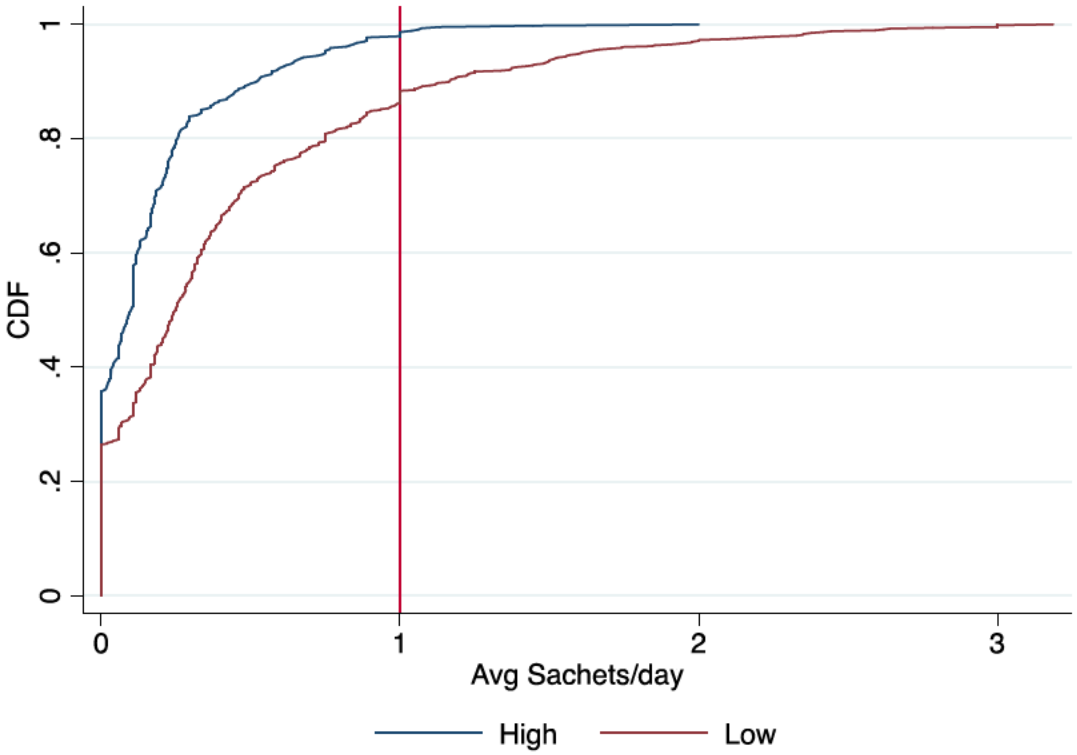


Figure 5 Cumulative distribution functions for average sachets purchased per day (three week moving average) by low price and high price treatment during phase one of market trial (weeks 1-17).

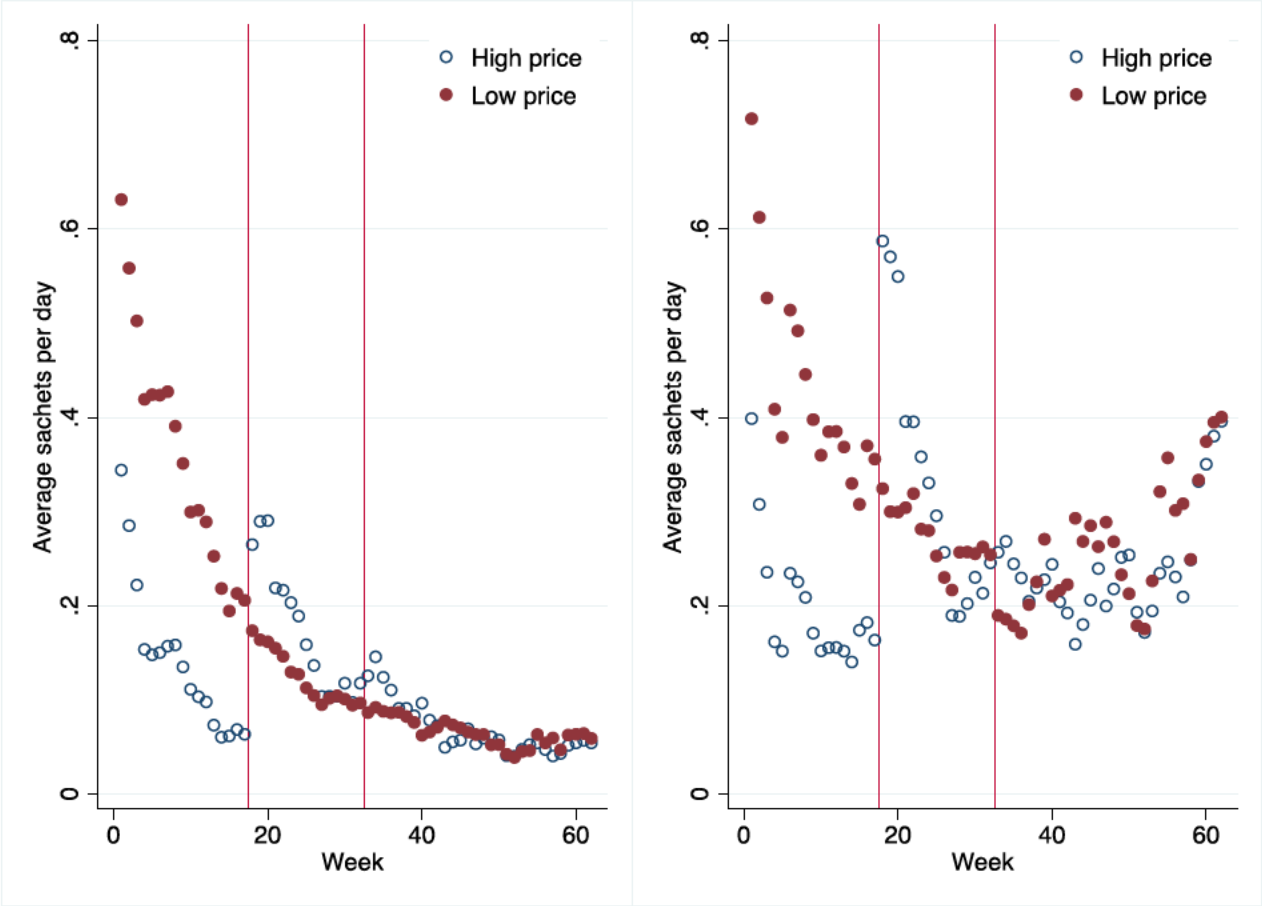


Figure 6 The average demand by week for initial high and low price villages. Weekly household-specific demand is measured as the three week moving average of sachets purchased per day. Vertical lines indicate the transition from phase one to two and two to three. The right panel uses the conservative 'inclusive' approach and the left panel uses the 'exclusive' approach to deal with weeks without a purchase.

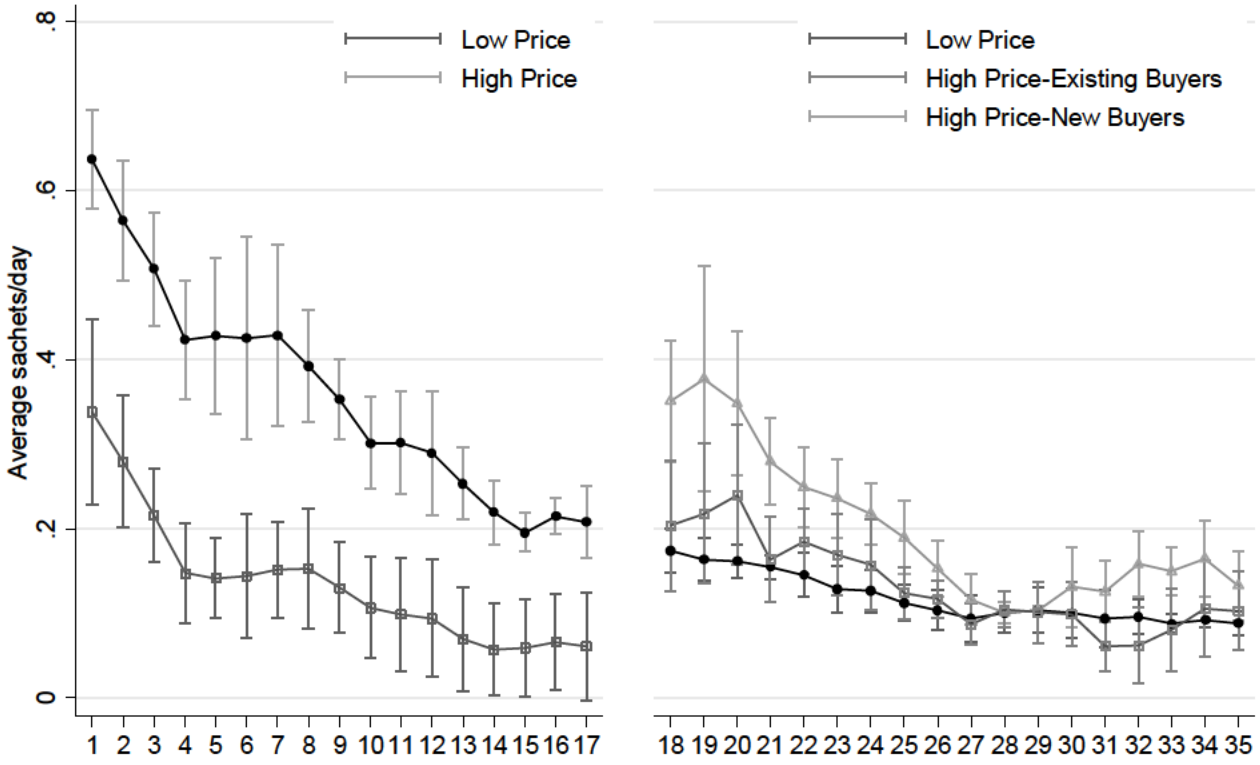
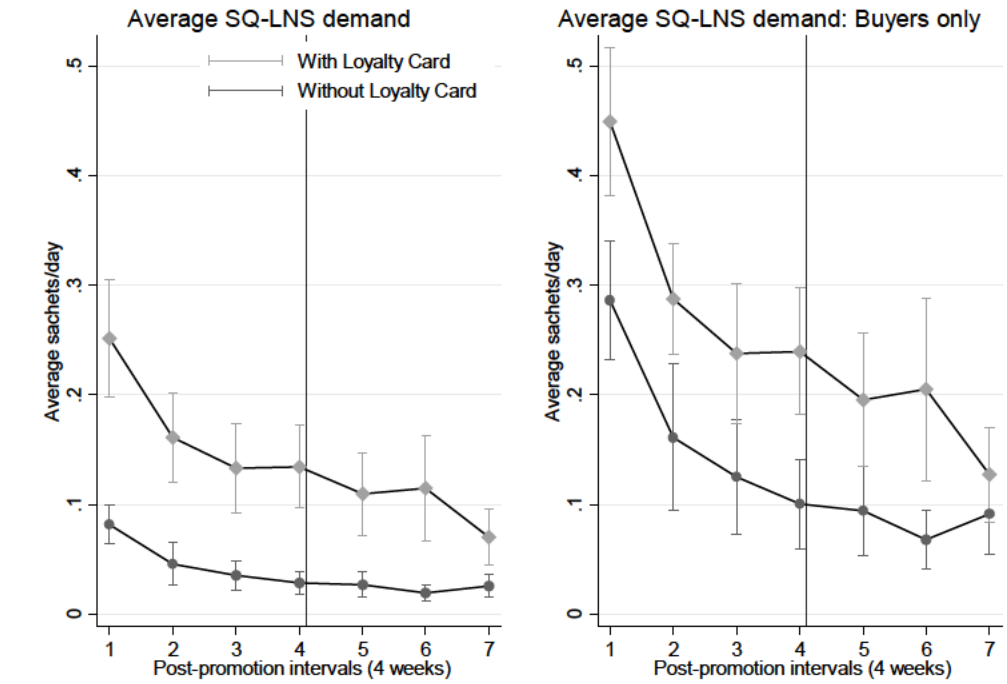


Figure 7 Average persistent demand (three-week moving average sachets per day per household) corrected for matched-pair fixed effects during phase one of the trial in high and low price villages (left panel) and after the price drop in high price villages for existing and new buyers in these villages (right panel). Bars depict 90% confidence intervals based on standard errors clustered by village-month.



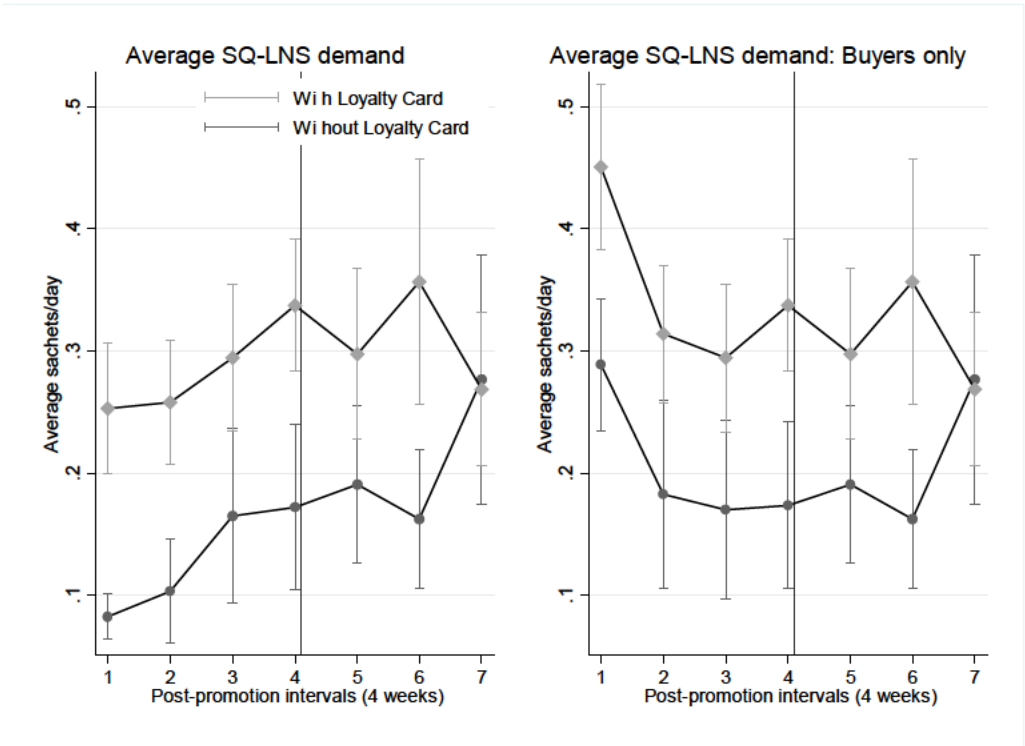


Figure 8 Conditional three week moving average of sachets purchased per day after promotional activities for households that won a loyalty card and those without a loyalty card, including all households that participated in the promotion (left) and only those that purchased at least one sachet of SQ-LNS after the promotion (right). Error bars depict 90% confidence intervals based on robust standard errors clustered by village. Vertical line indicates the earliest point that loyalty card holders could reach the maximum number of rewards. Top panel uses the 'inclusive' approach to deal with non-purchases; bottom panel uses the 'exclusive' approach.

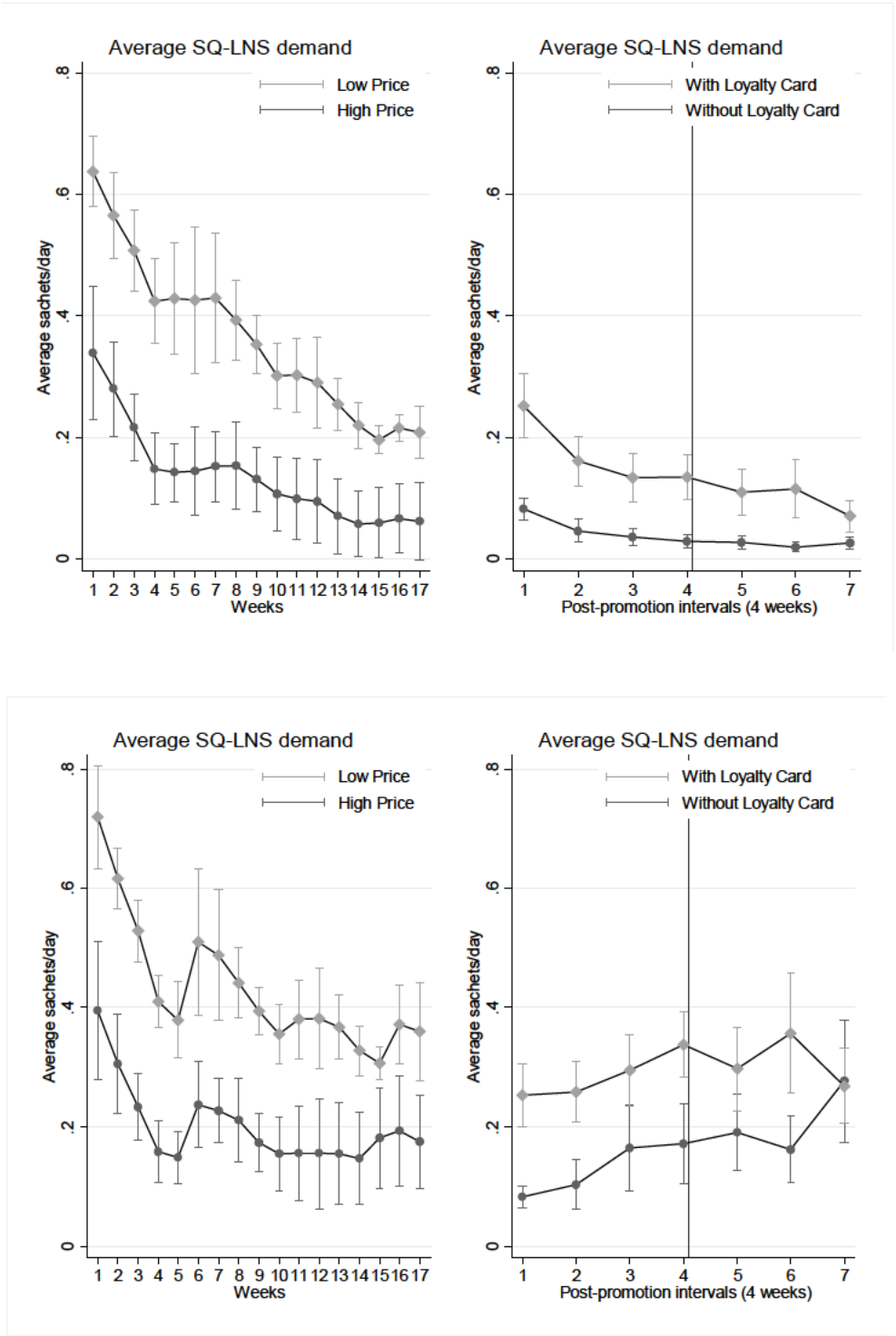


Figure 9 Comparison of average SQ-LNS demand during low price-high price phase one (left) and phase three with loyalty card (right). Low price represents a 50% reduction from high price. Based on the value of the small reward offered to loyalty card holders, this provides an effective in-kind price reduction of about 50% from the low price. Top panel uses the 'inclusive' approach to deal with non-purchases; bottom panel uses the 'exclusive' approach.

Table 1 Typology of differentiated LNS product classes

	Intended purpose	**Typical daily ration**	**Supply chain features**
Large-quantity LNS (Ready-To-Use Therapeutic Foods (RUTF))	Treat severe acute malnutrition (SAM).	180-280g (1000-1500 kcal) to provide 100% of energy demands for 9-12 month old child outside of breast milk.	Private sector production with public sector procurement (UNICEF, MSF, WFP) and public distribution in collaboration with national health programs. Distribution through markets often illegal.
Medium-quantity LNS (Ready-To-Use Supplementary Foods (RUSF))	Treat moderate acute malnutrition and prevent SAM.	45-90g (250-500 kcal) to provide 50-100% of energy demands.	Private sector production with predominantly public sector procurement (UNICEF, MSF, WFP) and public distribution in collaboration with national health programs. *Expected: Some private sector distribution through markets.*
Small-quantity LNS (SQ-LNS)	Prevent undernutrition; promote normal growth and development.	20g (110 kcal) to provide <50% of energy demands.	Private sector production. *Expected: Sparse public procurement and distribution and active private sector distribution through markets.*

Source: (Arimond, et al. 2013).

Table 2 Research design by phase and descriptive statistics disaggregated by voucher

							Source (% of voucher booklets distributed)									
			# Vouchers Distributed	# Active Vouchers	% Active Vouchers	Average Sachets per day	Auction (15%)		Auction + iLiNS Participant (15%)		Friend of iLiNS Participant (31%)		Vendor (28%)		Promotion (11%)	
							(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)	(1)	(2)
Phase 1	High price (H)		558	403	72%	0.13	57	32%	81	70%	190	100%	75	100%	-	-
	Low price (L)		913	740	81%	0.31	79	37%	122	75%	360	100%	179	100%	-	-
	Total		1,471	1,143	78%	0.25	136	35%	203	73%	550	100%	254	100%	-	-
Phase 2	H-L		859	467	54%	0.17	41	23%	76	50%	163	56%	186	78%	1	100%
	L-L		1,099	396	36%	0.11	32	15%	61	32%	148	35%	155	57%	-	-
	Total		1,958	863	44%	0.14	73	19%	137	40%	311	44%	341	67%	1	100%
Phase 3	H-L-L	w/ loyalty card	78	47	60%	0.13	2	100%	8	53%	4	80%	5	83%	28	56%
		w/o loyalty card	140	41	29%	0.03	4	40%	7	25%	5	42%	6	75%	19	23%
		Not in promo	982	374	38%	0.07	24	14%	38	28%	125	39%	185	53%	2	100
		Total	1,200	462	39%	0.07	30	17%	53	29%	134	39%	196	54%	49	37%
	L-L-L	w/ loyalty card	79	41	52%	0.13	6	55%	9	60%	1	50%	2	50%	23	49%
		w/o loyalty card	184	51	28%	0.04	4	27%	9	29%	8	57%	3	27%	27	24%
		Not in promo	1,183	355	30%	0.07	22	12%	39	22%	111	24%	182	50%	1	100%
		Total	1,446	447	31%	0.07	32	15%	57	26%	120	25%	187	49%	51	32%
	Total	w/ loyalty card	157	88	56%	0.13	8	62%	17	57%	5	71%	7	70%	51	53%
		w/o loyalty card	324	92	28%	0.03	8	32%	16	27%	13	50%	9	47%	46	24%
		Not in promo	2,165	729	34%	0.07	46	13%	77	25%	236	30%	367	51%	3	100%
		Total	2,646	909	34%	0.07	62	16%	110	27%	254	31%	383	51%	100	34%
Total	H		1,200	965	80.4%	0.10	78	44%	137	76%	336	99%	365	100%	49	37%
	L		1,446	1,158	80.1%	0.11	87	41%	172	78%	466	99%	382	100%	51	32%
	Total		2,646	2,123	80.2%	0.10	165	42%	309	77%	802	99%	747	100%	100	34%

Note: (1) # active vouchers; (2) % of distributed vouchers in cell that are active

Table 3 Overall community compliance and coverage rate by village and by initial price treatment

Initial Price	Pair	Village	Population	Target-age children	Overall community compliance rate	Voucher coverage rate	Active voucher coverage rate
High	1	Bakaribougou	3,631	198	5.1%	77.8%	66.7%
	2	Dande	13,941	760	4.1%	47.5%	38.0%
	3	Faramana	8,463	461	3.9%	69.4%	55.5%
	4	Fo	3,562	194	6.6%	69.1%	51.5%
	5	Padéma	3,749	204	7.4%	78.9%	64.7%
	6	Samandéni	3,362	183	3.9%	93.4%	72.1%
	7	Siankoro	3,401	185	3.1%	100.7%	81.3%
Low	1	Lanfièra Coura	3,190	174	6.0%	82.8%	72.4%
	2	Koundougou	8,324	454	3.9%	75.6%	61.5%
	3	Soungalodaga	2,694	147	5.1%	89.8%	68.0%
	4	Séguéré	2,636	144	1.4%	35.1%	18.9%
	5	Zangoma	4,202	229	3.4%	84.3%	67.2%
	6	Dawèra	3,989	217	4.8%	97.7%	83.4%
	7	Tarama	2,461	134	5.0%	82.8%	67.2%
Total			67,605	3,684	4.5%	76.3%	61.6%

Notes: 'Pair' indicates village pairings used for MPCR.

Overall compliance rate is computed as (average sachets purchased per village per day / target-age children).

Voucher coverage rate is computed as (total number of voucher booklets distributed per village/ target-age children).

Active voucher coverage rate is computed as (total number of vouchers used per village / target-age children).

Table 4 Estimated arc price elasticities of demand for SQ-LNS corrected for pairwise matching of low and high price villages.

	Estimate	Bootstrap SE	95% CI	
Overall elasticity	-6.0	(0.89)	-4.2	-7.7
Elasticity: first purchases	-4.2	(1.21)	-1.8	-6.6
Elasticity: repeated purchases	-7.7	(1.68)	-4.4	-11.0
Elasticity: within initial high price villages†	-6.0	(0.87)	-4.3	-7.7

† Includes six weeks before and after the 50% price reduction that occurred at week 17.

Table 5 Regression of three week moving average sachets per day purchases with buyer random effects for phase one of market trial.

	Treatment of Non-Purchases	
	Inclusive Approach	**Exclusive Approach**
Constant	0.21*	0.26**
	(0.120)	(0.130)
Low price village	0.37***	0.39***
	(0.078)	(0.077)
Voucher source: Auction+iLiNS	-0.053	-0.093**
	(0.039)	(0.040)
Voucher source: iLiNS	0.39***	0.49***
	(0.130)	(0.087)
Voucher source: Friend iLiNS	0.41***	0.46***
	(0.120)	(0.073)
Voucher source: Vendor	0.69***	0.74***
	(0.160)	(0.100)
F-test on Pair Fixed effects	8.89	16.58**
	[0.180]	[0.011]
Week FE	YES	YES
Week-Low price FE	YES	YES
Pair FE	YES	YES
Observations	15,603	13,649
Number of voucher	1,087	1,471

*** p<0.01, ** p<0.05, * p<0.1. Standard errors clustered by village-month in parentheses and p-value of F-test in [.].

Table 6 Regression of three week moving average sachets per day purchases with buyer random effects for all households that participated in promotional sessions and for 'new voucher' households that participated in these sessions but had not purchased SQ-LNS prior to the session. The 'pre-post promotion' column includes only households that had purchased SQ-LNS before participating in the promotional sessions and uses purchases before and after the promotion to estimate the loyalty card effect on demand persistence.

	Three week moving average sachets/day				
	Post-promotion		Pre-post promotion: Pre-existing buyers		
	All HHs in promotion	New buyers	All	High pre-promo demand†	Low pre-promo demand‡
Loyalty card	0.18***	0.17***	-0.0076	-0.07	0.034
	(0.065)	(0.062)	(0.110)	(0.250)	(0.060)
Post-promo			-0.057***	-0.20**	-0.015
			(0.022)	(0.098)	(0.014)
Loyalty card X Post-promo			0.17***	0.32*	0.12***
			(0.054)	(0.170)	(0.037)
… X Post-period 2	-0.053*	-0.045	-0.076	-0.095	-0.073
	(0.031)	(0.034)	(0.060)	(0.170)	(0.046)
… X Post-period 3	-0.071**	-0.065*	-0.086	-0.40**	0.042
	(0.032)	(0.035)	(0.056)	(0.160)	(0.054)
… X Post-period 4	-0.063**	-0.068**	-0.051	-0.29*	0.048
	(0.031)	(0.033)	(0.057)	(0.150)	(0.055)
… X Post-period 5	-0.086***	-0.097***	-0.062	-0.30**	0.045
	(0.031)	(0.034)	(0.056)	(0.150)	(0.054)
… X Post-period 6	-0.073**	-0.073**	-0.074	-0.24	-0.0023
	(0.033)	(0.034)	(0.063)	(0.170)	(0.056)
… X Post-period 7	-0.13***	-0.087**	-0.21***	-0.51***	-0.077**
	(0.030)	(0.035)	(0.045)	(0.130)	(0.033)
Second prize	0.015	0.037	-0.059	-0.051	0.016
	(0.025)	(0.024)	(0.077)	(0.200)	(0.039)
Male won loyalty card	-0.001	-0.046	0.21	0.65	-0.045
	(0.069)	(0.063)	(0.260)	(0.600)	(0.064)
Male won second prize	-0.0039	-0.041	0.069	0.007	-0.033
	(0.044)	(0.040)	(0.100)	(0.380)	(0.057)
>2 participants from HH	0.046	0.00051	0.14	0.27	-0.028
	(0.057)	(0.062)	(0.280)	(0.670)	(0.036)
Male participant from HH	-0.02	0.011	-0.12	-0.11	0.016
	(0.028)	(0.026)	(0.130)	(0.260)	(0.038)
Constant	0.16***	0.17*	0.35***	0.67***	-0.091
	(0.057)	(0.091)	(0.086)	(0.200)	(0.110)
Week FE	YES	YES	YES	YES	YES
Village FE	YES	YES	YES	YES	YES
Observations	14,330	10,008	6,144	1,519	4,625
Number of voucher	481	336	145	37	108

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors clustered by village in parentheses.

Unreported controls include post-promo period dummies and estimated week and village fixed effects.

†Average pre-promo weekly demand of more than 0.3 sachets/day.

‡Average pre-promo weekly demand of more than 0.3 sachets/day.

Table 7 The effect of rainfall fluctuations (measured as z-scores relative to long-run cumulative rainfall by week) on weekly demand and demand persistence for SQ-LNS.

	Phase 1: July-Nov 2013		Phase 3: Mar-Aug 2014	
	Sachets purchased (weekly)	Three week moving average sachets/day	Sachets purchased (weekly)	Three week moving average sachets/day
Low price village	0.0723	0.0325		
	(0.512)	(0.126)		
Loyalty card			0.770***	0.109***
			(0.143)	(0.032)
Cumulative rainfall (z-score)	1.824***	0.193***	-0.0186	-0.00385
	(0.453)	(0.058)	(0.049)	(0.005)
…X Low price village	-1.521***	-0.215***		
	(0.493)	(0.062)		
…X Loyalty card			-0.261***	-0.0302***
			(0.075)	(0.011)
…X Planting			0.132**	0.0168**
			(0.066)	(0.008)
…X Growing			0.0525	0.0108
			(0.061)	(0.008)
…X Maize harvest	-0.693	-0.064	0.197	0.0266*
	(0.475)	(0.071)	(0.133)	(0.015)
…X Other harvest	-0.613	0.0189		
	(0.593)	(0.100)		
Constant	4.959***	0.816***	4.671***	0.628***
	(0.963)	(0.214)	(1.585)	(0.210)
Village FE	YES	YES	YES	YES
Village Pair FE	YES	YES	-	-
Observations	15,603	15,603	14,330	14,330
Number of vouchers	1,087	1,087	481	481

*** p<0.01, ** p<0.05, * p<0.1. Robust standard errors clustered by village in parentheses.

Table 8 The effect of observable household characteristics on average demand persistence for SQ-LNS based on endline sub-sample.

	Average sachets/day	# Weeks with sachets/day>0.3	Overall average >0.3 sachets/day	Total purchases <7 sachets
Household size	-0.00043	0.012	0.0012	0.0018
	(0.002)	(0.083)	(0.003)	(0.0061)
Asset index	0.028**	0.42	0.054***	-0.00084
	(0.011)	(0.410)	(0.016)	(0.024)
Hunger score	0.0076	-0.14	0.014	-0.13***
	(0.019)	(0.960)	(0.036)	(0.026)
Most of food is home produced	0.023	0.9	0.032	-0.021
	(0.028)	(1.510)	(0.040)	(0.060)
≤Half of food is home produced	0.057*	2.7	0.11**	0.015
	(0.028)	(2.090)	(0.050)	(0.083)
Low price village	0.017	-0.61	0.086*	0.069
	(0.029)	(1.460)	(0.044)	(0.055)
Father involvement index	0.063	4.01*	0.075	-0.13
	(0.048)	(2.200)	(0.081)	(0.092)
Constant	0.082***	6.97***	-0.012	0.34***
	(0.024)	(1.680)	(0.032)	(0.11)
Observations	335	335	335	335
R-squared	0.032	0.024	0.056	0.033

Robust standard errors clustered by vendor in parentheses.

*** p<0.01, ** p<0.05, * p<0.1

Supplementary Figures and Tables

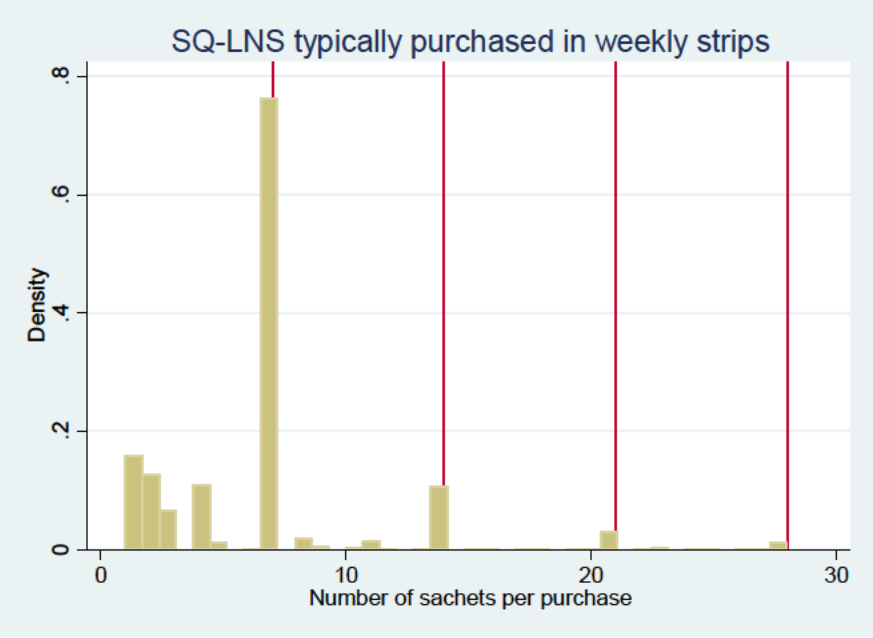


Figure S1 Number of sachets purchased per transaction with modes at multiples of weekly strips

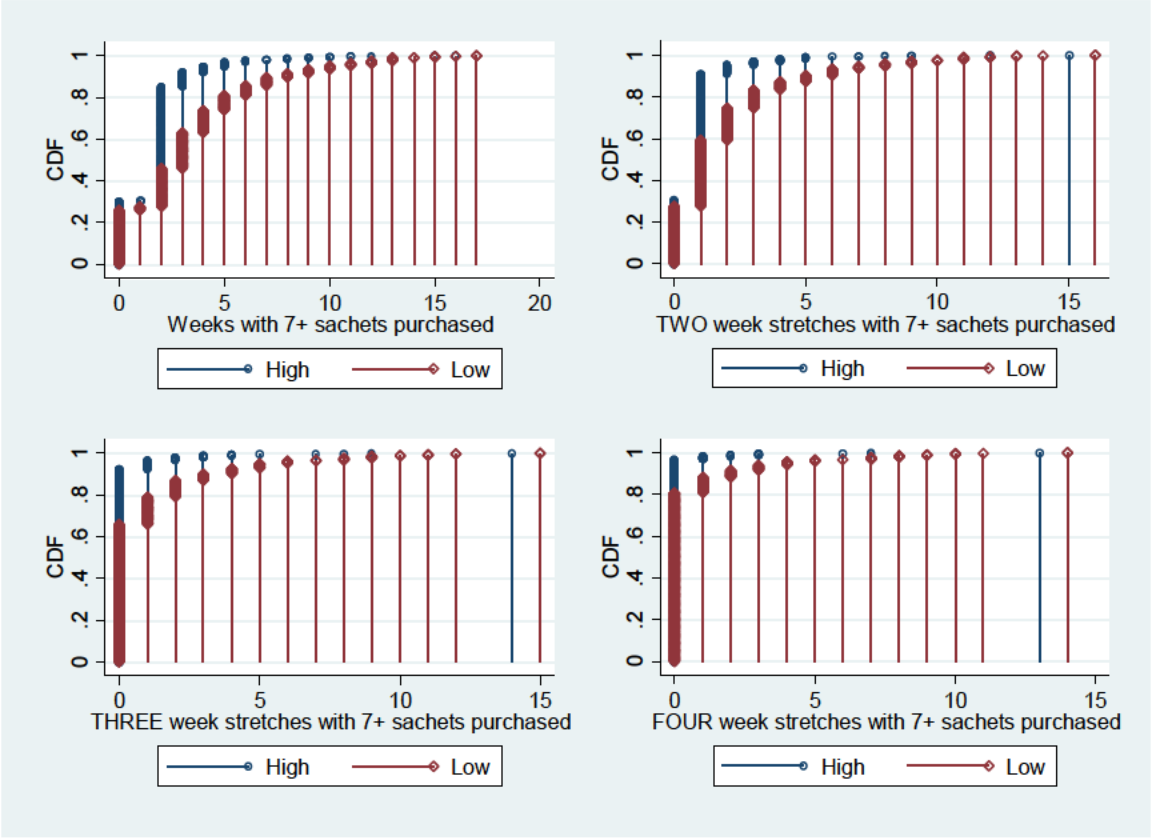


Figure S2 Cumulative distribution functions of consistent daily purchases by low price and high price treatment during phase one of market trial (weeks 1-17).

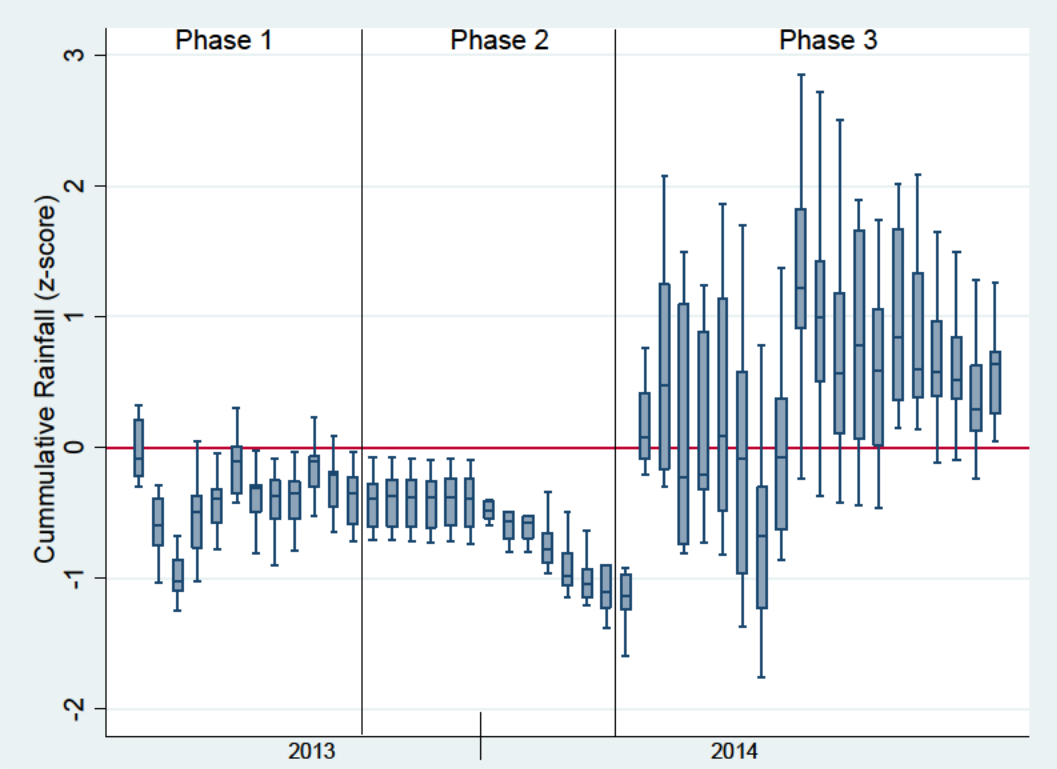


Figure S3 Box plots of cumulative rainfall relative to long-run average (z-scores) across 14 villages included in the market trial measured in 10-day intervals.

Appendices

Appendix A: Experimental Auctions for SQ-LNS

Auction participants were recruited via town crier the day before and the day of the auction. The crier announced the iLiNS team was in the village and wanted to speak with mothers and father of children age 6-24 months. Potential auction participants were screened for eligibility, and then eligible and willing participants received a participation fee (double the local daily wage rate) and were given some basic information about SQ-LNS and its potential benefits.

The protocol followed during each auction session is described in detail in the Auction Protocol, below. In short, participants were given an opportunity to purchase a week's supply of SQ-LNS for their children. Incentive-compatible WTP was elicited using a discrete version of the Becker-DeGroot-Marschak (BDM) mechanism in which participants were asked if they would be willing to pay specific, incrementally-increasing prices for a week's supply of SQ-LNS. Once a participant indicated s/he would not be willing to pay a specific price, his/her maximum WTP was recorded as the previous price in the series, and the participant purchased SQ-LNS if his/her maximum WTP was at least as high as a (subsequently revealed) 'market' price.

Because the efficacy of SQ-LNS likely depends on regular consumption throughout early childhood, we also asked a series of follow-up questions about WTP in the long-term. Specifically, we asked if a participant would pay his/her maximum WTP for SQ-LNS each week until his/her child was 24 months. The price was then increased/decreased in small increments, and the price at which the participant changed his/her answer was recorded as his/her long-term hypothetical WTP.

Table A1 presents descriptive statistics of anthropometric, demographic, and economic data collected during these auctions.[25] Using these data, we explore the determinants of both incentive-compatible WTP for a week's supply of SQ-LNS and long-term hypothetical WTP. We model WTP for a week's supply using a Tobit maximum likelihood estimator, as the discrete BDM mechanism employed in the auctions means WTP is censored from above at the highest price in the price series. Long-term hypothetical WTP, which is not censored, is modeled using ordinary least squares. Although the series of auction sessions were designed to be as similar to one another as possible, small differences across sessions due to factors such as the composition of men and women, questions that arose during a session, or other session-specific factors could lead to correlation in bids among participants in a particular session. To

[25] Principal component analysis was used to combine household ownership of a set of assets[25] into an asset index (Vyas and Kumaranayake 2006). 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 food security score between 0-15 based on how frequently the household experienced each of five food insecurity conditions in the past four weeks, where higher scores indicate higher levels of food insecurity.

account for this, standard errors are clustered at the auction session level (Cameron and Miller *Forthcoming* 2015). Results are presented with and without auction session fixed effects in Table A2.

Across both specifications one and two in Table A2, incentive-compatible WTP for a week's supply of SQ-LNS is lower, all else equal, among households that previously participated in the iLiNS-Zinc clinical trial. All participants in the clinical trial received SQ-LNS for free (either as part of the clinical trial or after the clinical trial as part of a control group), so these households had extended, first-hand experience with SQ-LNS prior to the auction. The negative association with WTP for SQ-LNS relative to participants who were not part of the clinical trial may be a reflection of these households' knowledge of the short-term private costs and benefits of SQ-LNS. Because SQ-LNS was provided for free to households who participated in the clinical trial, the negative relationship may also reflect a price anchoring effect whereby WTP is "anchored" to the previous price of zero.

Other statistically significant determinants of WTP for a week's supply are participant gender, weekly income, television ownership, and the asset index. WTP for SQ-LNS is higher, ceteris paribus, among male auction participants in the fixed effects specification, while the relationship between the household asset index and WTP is negative in this specification. Household ownership of a television is positively associated with WTP in the specifications with and without fixed effects. Participant income is negatively associated with WTP without fixed effects, but the magnitude of the effect is quite small.

Like WTP for a week's supply elicited from the auction, long-term hypothetical WTP for SQ-LNS is lower, all else constant, among households who participated in the clinical trial and higher among male participants. Household food insecurity is negatively associated with long-term WTP, where more food *in*secure households have a lower willingness to pay, all else equal. In specification three without fixed effects, the association between the age of the participant's youngest child and WTP is positive and significant.

Table A1 Descriptive statistics for households participating in the experimental auction.

	Variable	Definition	Mean/ Frequency	Std Dev/ Percent	Min, Max
Auction Participants	Male	=1 if participant is male	259	52.3%	
	Education	Years of education	1.9	1.9	0, 5
	Weekly Income	Self-reported income in past seven days (4^{th} quarter 2011 USD)	22.89	72.1	0, 784.6
	Height	Height in meters	1.68	0.1	1.4, 1.9
	BMI	Body mass index (weight/height^2)	21.8	2.7	16.2, 34.3
Auction Households	Household Size	Number of household members	8.0	3.9	2, 27
	Child Age	Age of participant's youngest child in months	13.1	5.1	5, 24
	PC Weekly Food Expenditures	Per capita household expenditures on food in the past seven days (4^{th} quarter 2011 USD)	1.22	2.6	0, 42
	TV	= 1 if household owns a television	91	18.4%	
	Asset Index	Proxy measure of household's socioeconomic status based on asset ownership	0.0	1.0	-4.5, 1.3
	Food Insecurity Score	Indicator of food insecurity in the household	1.8	2.4	0, 11
	Clinical Trial Household	= 1 if household participated in the iLiNS-Zinc clinical trial	103	20.8%	
WTP	Auction WTP	WTP for week's supply of LNS (4^{th} quarter 2011 USD)	0.85	0.29	0.10, 1.18
	Auction hypothetical long-term WTP	Long-term WTP for week's supply of LNS (4^{th} quarter 2011 USD)	0.75	0.51	0.10, 4.86

Table A2 Tobit regression results of WTP elicited in experimental SQ-LNS auction

	Variable	WTP for a Week's Supply		Long-Term Hypothetical WTP	
		(1) No Fixed Effects	(2) Fixed Effects	(3) No Fixed Effects	(4) Fixed Effects
Participant Characteristics	Male (0/1)	0.0733	0.1042	0.1913***	0.2418***
		(0.0494) ‡	(0.0651)	(0.0611)	(0.0846)
	Education (yrs)	0.0088	0.0024	-0.0022	-0.0046
		(0.0110)	(0.0113)	(0.0148)	(0.0159)
	Weekly Income (2011 USD)	-0.0003*	-0.0002	-0.0001	-0.0000
		(0.0002)	(0.0002)	(0.0002)	(0.0002)
	Height (meters)	-0.2856	-0.1662	0.0196	0.1606
		(0.3306)	(0.3261)	(0.2962)	(0.2717)
	BMI	0.0024	0.0017	0.0097	0.0063
		(0.0077)	(0.0077)	(0.0085)	(0.0091)
Household Characteristics	Household Size	-0.0031	-0.0064	-0.0069	-0.0104
		(0.0049)	(0.0054)	(0.0050)	(0.0062)
	Child Age (mo)	0.0026	0.0006	0.0079**	0.0061
		(0.0033)	(0.0031)	(0.0033)	(0.0042)
	PC Weekly Food Expenditures	-0.0035	-0.0023	-0.0034	-0.0029
	(2011 USD)	(0.0061)	(0.0056)	(0.0069)	(0.0064)
	TV (0/1)	0.0963**	0.1073**	0.0692	0.1074
		(0.0444)	(0.0492)	(0.0719)	(0.0752)
	Asset Index	-0.0488*	-0.0663**	-0.0016	-0.0219
		(0.0258)	(0.0282)	(0.0327)	(0.0355)
	Food Insecurity Score	-0.0114	-0.0147	-0.0290**	-0.0307**
		(0.0100)	(0.0104)	(0.0118)	(0.0127)
	Clinical Trial Household (0/1)	-0.1023**	-0.0968**	-0.1711**	-0.1722**
		(0.0422)	(0.0443)	(0.0634)	(0.0695)
	Constant	1.2520**	1.0310*	0.3491	-0.8355*
		(0.5309)	(0.5531)	(0.4104)	(0.4208)
	Sigma	0.3915***	0.3753***		
		0.3915***	0.3753***		
	N	495	495	494	494
	Pseudo R^2/ R^2	0.028	0.085	0.084	0.155

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

Models specifications: (1) is tobit and does not include fixed effects; (2) is tobit and includes auction session fixed effects; (3) is OLS and does not include fixed effects; (4) is OLS and includes auction session fixed effects.

Note: Controls for market price in the practice rounds are included in all regressions (unreported).

‡Numbers in parentheses are robust standard errors, clustered at auction session level.

Appendix B: Detailed Description of SQ-LNS Market Trial

The market trial was carried out to estimate the demand for FD. A detail description of the market trial data is presented in the following order: 1) Vendors, 2) Vouchers, 3) Price/Villages, 4) Participants, and 5) data collection.

1. Vendors:[26]

Randomly selected vendors in 14 difference villages, of the 34 villages where the FD study was carried out, were invited to participate in the study as official vendor sites for FD. Out of all the invited, 29 official vendors sold FD during the 62 week trial.

The total number of sales that each vendor sold during the entire market trial is presented in Figure 1.

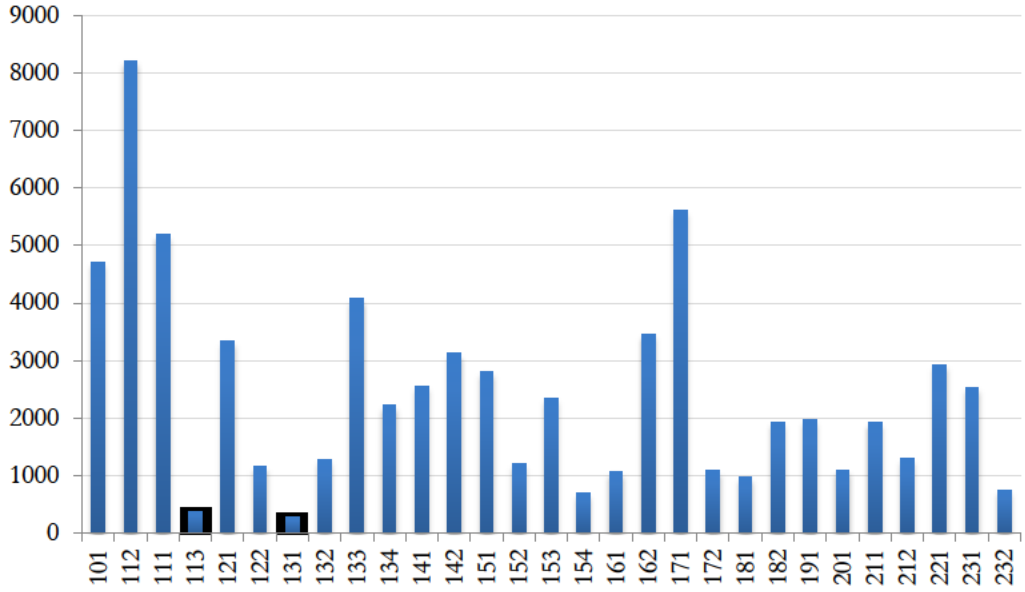


Figure 1: Distribution of sales by vendor during the entire market trial

Vendors were walked through a consent process in which they were assured that participation in the study is voluntary and they may withdraw their consent at any point in the study without penalty or negative consequences. If vendors were not able read or write, they were instructed to provide their consent using their fingerprint, at which point they received assistance from a witness, unaffiliated with the study, to explain the consent form and sign, verifying that the vendor understood the conditions and freely agreed to participate in the study.

Vendors who decided to participate had 5 main tasks:

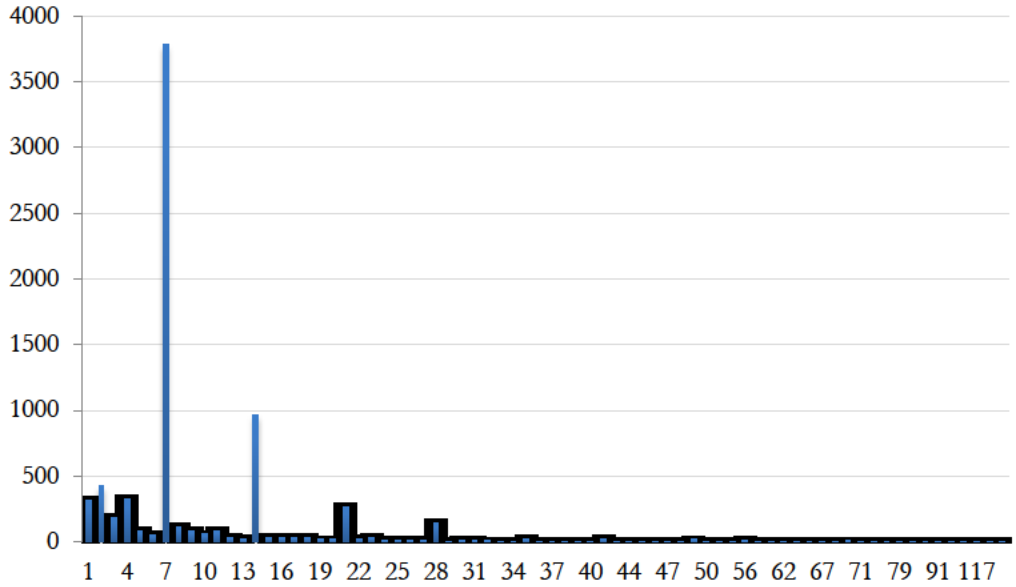
[26] Consent form and script are available upon request.

a) Promote FD: to promote FD to people who come into the shop, each vendor received 2 posters to hang in the store and outside. The picture in the poster showed a mother and her two children representing the age range for the consumption of FD. The main characteristics of the product that vendors have to give to potential buyers were the following: 1) FD does not replace a diverse and nutritious meal; 2) they should breastfeed the child before giving him/her FD; 3) they should mix FD with a small portion of the child's food; 4) FD promotes growth; 5) FD promotes good child development; and 6) 1 bag, 1 child, 1 day. All this information was given in the form of "dominoes" that were distributed during the first purchase to a checkbook holder.

   Additional important messages that vendors knew and communicated to the potential buyers were: FD should not be given to a child under 6 months; it is not a medicine but a food supplement; reseal open bags and keep them in a clean place away from insects; FD should not be given to children allergic to milk (industrial or animal) or peanuts; and some children, when they first take FD, may have diarrhea, if the signs persist after three days they must stop consuming FD. After 3-6 days caregivers can start giving the child FD again and if the child has diarrhea again, caregivers must permanently stop giving FD to the child.

b) Sell FD at the price set by the FD team (section 3)

   Limitation of the quantity sold: The maximum quantity to be sold to an individual is that of a month (4 strips or 28 bags), and costumers needed to provide a concrete justification for this purchase (like traveling). Figure 2 shows that the mode of purchases was 7 sachets per week. However there were 3 sales that were of amounts of more than 100 sachets at one.



c) Distribute checkbooks for voluntary purchases and collect a minimum of information on the people who receive it.

For this, each vendor received a stack of checkbooks for voluntary purchases to people that didn't have a checkbook already. Each household had a unique number and they couldn't have two numbers. Before giving out a new checkbook, vendors had to make sure the buyer has never received a checkbook.

The vendors needed to get information of "volunteers" so the FD team knows whom these new buyers were in order to follow their purchase behavior. The minimum information that vendors needed to collect to be able to find that person was their name, village, district, phone number, and name of head-of-household or concession. This information was recorded on the back of the first purchase coupon.

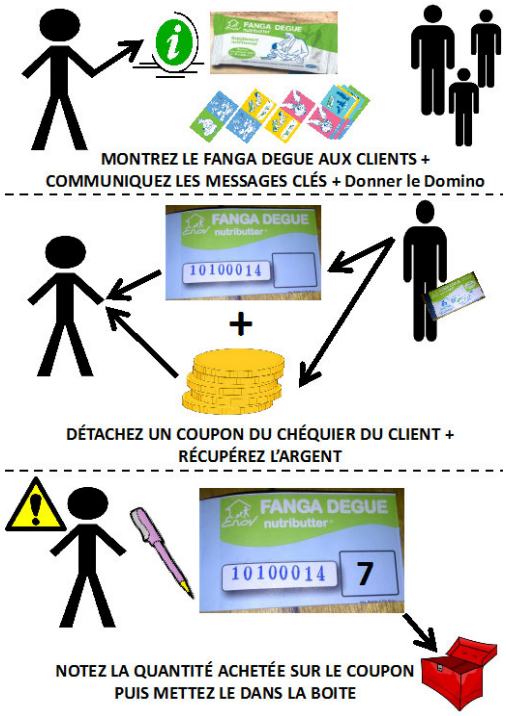
To facilitate the identification of "voluntary buyers," the checkbooks given to vendors were limited. The vendor was also responsible for informing the FD team when a buyer's checkbook was almost finished so that a new checkbook with the same identifying number could be issued.

d) Collect coupons from buyers for every purchase of FD.

In order to track purchase behavior, every costumer that wanted to buy FD needed a checkbook. Each time the customer purchases FD, vendors had to detach a page from the checkbook and mark the amount of sachets of FD bought and keep the coupon in a plastic bucket that was provided to them.

The coupons that vendors kept, allowed the FD team to count the amount of FD sold and calculate the vendors' compensation. It was therefore very important to not sell FD to people who do not present their checkbook. If a costumer didn't have a voucher, the vendor gave him/her one new checkbook (step c).

To facilitate the separation of monetary accounts of FD sales and other products in the store, a working capital of 300 CFA francs (in 25 or 50 francs) were given at the beginning of the sale to vendors. All sales had to be in cash (no credit).



e) Collaborate with the FD team who was there to assist sellers and visited them 1-2 times a week.

The FD team was available whenever vendors needed support. The vendors received 10 Frs. CFA (0.02 USD) for each sachet sold. This amount is the same for all the vendors regardless of the selling price in the village. Sellers received their compensation every monthly, which was calculated from the accounts made twice per week by the FD team.

At each visit, the FD team collected and counted the revenue from the week's sales. After the first week, vendors were charged either 25 or 50 Frs. CFA for any missing sachets. FD team checked that the revenue collected matched both the inventory count and the number of sachets sold as indicated on the coupons collected. At the end of the visit, the FD team made sure that the vendor was left with the appropriate change (300 Frs. CFA in small denomination).

[Check Vendor Consent form: ENG D01E - Vendor consent form]

[Check D05 Feuilles annexes pour le compte avec les vendeurs – record sells]

[Check D06 – shop visit report – weekly visit report]

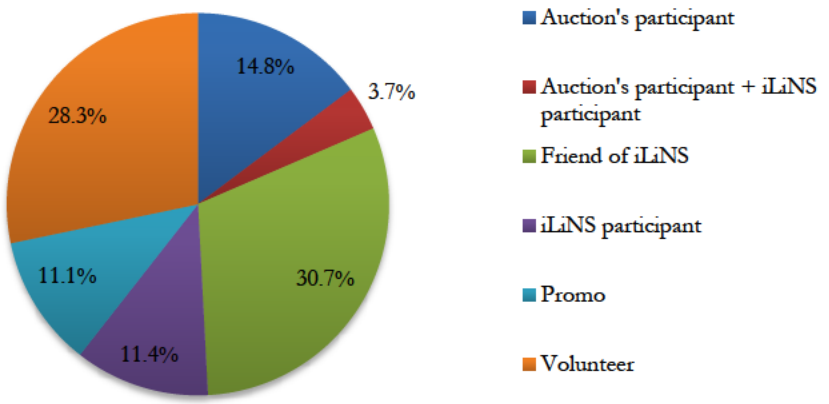
2. <u>Voucher:</u>

Each checkbook had a unique number that allowed the FD team to track purchases made by its owner, to know who is buying FD and at what pace.

Coupon numbering system: each coupon was marked with an eight-digit code, which identify the village (first two digits), source of the coupon (third digit), participant id (the following four

numbers), and if the participant was a friend of an iLiNS participant (last digit. The last number had a number 1, 2 or 3, if the checkbook was given to the 1st, 2nd, or 3rd friend of an iLiNS participant respectively. If the checkbook was acquired in any other way, this number was "4".
The checkbook's color was also linked to the source of the coupon: Auction participant (blue, #1), Auction & iLiNS participant (blue, #2), iLiNS participant (red, #3), iLiNS friend (red, #4), Volunteer (#6), and Promo (#6).

Figure 3 presents the distribution of the source of the checkbooks that were used at least once. Figure 4 is an image of how the voucher looked.



3. Villages and Price

Out of the 34 villages that were part of the iLiNS study, 14 villages were chosen to do the market trial: Bakaribougou (#10), Dandé (#11), Dawera (#12), Faramana (#13), Fô (#14), Koundougou (#15), Lanfiéra Koura (#16), Padema (#17), Samandeni (#18), Siankoro (#19), Séguéré (#20), Soungalodaga (#21), Tarama (#22), and Zangoma (#23).

Two different prices were charged in the 14 villages where the study was conducted in order to know if price differences have a significant impact on purchases. For the first 17 weeks of the trial, half of the villages (7) had a high price per set of 7 sachets of FD (300cfa or 50 Frs per sachet) and the other half had a low price per set of 7 sachets of FD (150cfa or 25 Frs per sachet). After the first 17 weeks, every village had the same price.

The villages with the low price were: Bakaribougou (#10), Dandé (#11), Faramana (#13), Fô (#14), Padema (#17), Samandeni (#18), and Siankoro (#19).

4. Participants

Any person with a voucher could go to an authorized vendor and buy FD at a determined price for 62 weeks.

There were five ways to access a checkbook: 1) Having participated in an auction with some parents in the village during the month of June; 2) Having a child who participated in the FD study; 3) Being the parent/friend of the family who participated in the FD study, (3 checkbooks were given to each FD participant to distribute to their families/friends); 4) the promotional sessions; and 5) Get a checkbook directly from the vendors.

5. Data collection

Data collection begins with the agents upon visiting the vendor. The agent collected and recorded information from the coupons, including the ID number, total number of sachets purchased, strips purchased, single sachets purchased, prices for strips and individual sachets, and the total price for the purchase. The agent totaled each of these columns on site then counted the inventory to address any discrepancies between the inventory and reporting during the visit.

Coupons were collected weekly or twice a week when the FD team visited the vendor as a part of the accounting process. The coupons, money, and forms were brought back to the office in Bama for data entry, review, and storage.

They also collected information from the checkbooks distributed for voluntary purchases and renewals of checkbooks. For this, a notebook was available for the vendor to record information (names, phone numbers) which was later given back to the FD team as supporting evidence for the point of sales of FD and the calculation of the vendors' compensation.

Appendix C: Phase Three Promotional Sessions

1. Promotional session

Goal: The goal of the promotional session was to: 1) boost demand for the FD by having the information activity and games, and 2) Test the impact of the loyalty program (=card), through a non-financial intervention, on demand for FD.

Location: The promotional sessions were carried out during market days in each of the 14 villages with authorized vendors: Bakaribougou, Dandé, Dawera, Faramana, Fo, Koundougou, Lanfiera Koura, Padema, Samandeni, Siankoro, Seguere, Soungalodaga, Tarama, Zangoma. For medium and large villages, several sessions (3-4) were carried out. For small villages, 2 sessions were given, or a "big" session with a small introductory session

Invitation: Participants were invited by the town crier the night before the session with the following message: "The FD team invites the fathers **AND** mothers that have children who are between 6 and 24 months old to participate in a discussion session during the market day at ___ h.

Sample: 15 to 60 people on average by villages depending on the size. For the 15-60 participants per villages, the goal was to have a 50-50 distribution between men and women. Therefore, it was very important to insist the crier to deliver the message to fathers and mothers.

Day of the session: The sessions were organized as a discussion/information session with the majority of the participants sitting down in an arranged way, which facilitates the delivery of the information. To accomplish this, each participant was greeted and seated, answered the enrollment questionnaire (D07), and they received a piece of paper with a number (which is written down in the questionnaire).

Once every participant was accommodated, the presenter introduced FD in the form of questions-and-answers. For the first part, the FD was presented to the audience and after that, 6 to 10 major questions were answered. The sessions were interactive, which meant that the presented made sure that participants were listening and understanding the main points of the presentation.

The principal language was Dioula, but questions could have been asked in other languages.

During the information session, another team was reviewing the enrollment questionnaires to identify targeted people who were eligible to spin the wheel. Targeted participants were eligible to spin the wheel and were informed that they were chosen as targeted participants to play the game.

2. Eligible Participants

Each session had an equal number of fathers and mothers who have children between 6 and 24 months old. However, other interested people were welcomed to listen to the informational session and were randomly selected to complete the minimum requirement of people needed to spin the wheel. Specifically, if the sample was not reached, the FD team selected a man/woman that is part of the household/concession that have a child/children who are between 6 and 24 months old.

3. The Game and Rewards

Selected participants spin the wheel in order to get a gift in front of everybody to see the outcome as evidence (at the end of the information session).
The 3 kinds of gifts that they could win were:

1. 1 set of FD + 1 FD sticker + 1 checkbook if he/she didn't have one.
2. FD t-shirt + 1 FD sticker + 1 checkbook if he/she didn't have one.
3. FD t-shirt + 1 FD sticker + 1 checkbook if he/she didn't have one + 1 FD loyalty card + a hook for empty bags.

The loyalty card: if the participant presents 28 empty sachets with the loyalty card, he/she won a gift. They could win up to 4 times. The 4 different gifts obtained were: OMO, BOL, SUGAR & MILK, and a copy of the picture taken.
The hook it is a toy to hang empty bags.

The participants, who spin the wheel, answered a second questionnaire (D08) to collect information about their socioeconomic characteristics.
Also, for those who won the loyalty card, a picture was taken (after obtaining their consent) to facilitate monitoring. A copy of the photo was provided to them at the end of the activity.

[Check: D07 - Fiche d'enrôlement pour les AP_EZ]

[Check: D08- Données Socio Economiques AP_EZ]

Appendix D: Endline Sampling Procedures

1. Sampling procedure:

The 375 participants who were part of the end-line survey were selected with the following sampling procedure:

- Buyers who started after week 40 were excluded from the sample.
- Remaining buyers were sorted from greatest to least by the ratio of total units bought and days as a client.
- The top 15% of buyers were identified and labeled with the letter A; the bottom 85% were labeled with the letter B.
- Out of all the buyers in this sub-population, 25% were chosen randomly. Group A was over-sampled to get more high-frequency buyers. The goal was for the "top 15% buyers" (A) to make up 25% of our sample and the "bottom 85% buyers" (B) to fill out the remaining 75% of the sample.
- The number of total participants in each village (N) was identified and also the number of participants in the top and bottom brackets. A pattern was design to choose randomly the participants (for example, take 1, skip 2, take 1, skip 3) and get the correct number of clients from each bracket in every village.

Adding Friends of Friends: All buyers who were friends of an iLiNS participant were added to the sample (N=113). The original iLiNS household was not.

2. Finding Clients/Recruiting

Once the sampling was finalized, the FD team prepared a list of the selected buyers with all the information available from the checkbooks (name, phone, location), iLiNS, auction records, promos, vendor supplied info, and the date of their last purchase. This was a tool to help agents for recruiting. The date of the last purchase was used to jog the memories of vendors: "this client purchased for the past 3 months" or "only last July," etc.

Many iLiNS households were located and asked about the checkbooks that they had to distribute to their family and friends. They answered several questions, among them: "why these friends and not others?"; information of their friends like name, phone, location, relationship to iLiNS households, and their checkbook numbers once they were located so FD team could link person/household to checkbook.

Reasons for exclusion from sample: (N=46)

- Moved far away
- (For friends) iLiNS family moved away, no info on friends
- ILiNS family cannot remember who they gave checkbook to
- The checkbook got lost
- Child died

- Data entry error found regarding checkbook number
- Vendor doesn't remember who client is
- Checkbook was given back to vendor
- No information on checkbook to begin search
- Lives in Ouaga
- Client had another checkbook when found, replaced bad checkbook number with one in hand, voucher data replaced in sample.
- Checkbook registered to wrong person. If person found but not the checkbook, that number was replaced in sample with one person is using/holding.

3. Data collection: 500 people

- Recruiting happened between: 7/24 – 8/6.
- 6 agents and 12 assistants were hired: 7/29 – 8/6
- Ayoro went to the field to collect data from agents. He distributed the client survey to the agents to read over night.
- Training & Pilot Testing: 8/7 – 15
- Conduct Surveys: 8/18 – 9/5
- Data Entry: 8/20 – 9/12

4. Survey instrument:

[Check: Local Demand Assessment Follow-Up_Client Survey_08-14-2014_EZ - TRANSLATE]