Essays in Maternal and Child Health Economics

Essays in Maternal and Child Health Economics

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Abstract

Overall, this dissertation studies important issues around the early years of our lives, both in developing and developed countries. With coauthors I first look at how maternity and neonatal care are influenced by what else is going on while a woman is laboring in a hospital. Analyzing a robust dataset covering a 16 year period in Philadelphia, we find that the busyness of a labor floor – measured by the number of other women on the floor – has meaningful adverse effects on the risks of use of interventional procedures such as cesarean sections and of adverse maternal health outcomes. There is no association with adverse neonatal health outcomes, suggesting that the increased use of interventional procedures may be unnecessary from a medical perspective.

After this analysis, I turn to the first years after children are born. During this period nutritional intake is especially important due to the lifetime consequences on cognitive development, health, and physical development. With this motivation, I study the effects of two randomized interventions targeting child nutritional intake in Ethiopia. In the first experiment, with coauthors I analyze how behavioral techniques can be used to translate the development of improved crop varieties (Quality Protein Maize, in this case) into actual behavior change and improvements in nutritional status. Prior efforts in this space have resulted in the development of numerous improved crop varieties that improve children's nutritional status in controlled settings, but little effect on children in real-world settings. We find that educating caregivers and household heads about the importance of keeping improved crop varieties separate for their

young children, combined with tools for earmarking and labeling the grain, effectively improves a number of intermediate outcomes, including the children's consumption of the improved crop varieties and the caregivers' cooking and food storage behaviors. However, there were no meaningful improvements in the children's nutritional status.

In the second experiment, I build on the first trial to study how small nudges grounded in behavioral economics can be used to improve young children's overall nutritional intake and nutritional status. Specifically, I build on the finding during the first trial that caregivers were often unaware of or unconcerned about their child's poor nutritional status (i.e., height) and analyze the impact of providing personalized information about the children's nutritional status to caregivers. Given the economic constraints of the region, I pair this with an orthogonal cash transfer intervention, where the cash transfer is labeled as being specifically for additional food for the young child. I find that both interventions were effective in increasing the children's consumption of eggs, a key underutilized source of protein in the context. However, the cash transfer was generally more effective in terms of effect size and diversity of impacts (i.e., relevant outcomes other than egg consumption). Both interventions led to improvements in the children's sex- and gender-standardized weight.

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Chapter 1: The impact of overlapping patients on intervention rates, maternal and neonatal morbidity in childbirth

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Abstract

Importance: Hospital labor and delivery units can experience large fluctuations in busyness due to rapid turn-over in patient census. When there is a high number of overlapping patients, staff and other safety-critical resources are less available. The relationship between short-term increases in busyness and patient safety is understudied.

Objective: To investigate the impact of overlapping patients on the labor floor on intervention rates, maternal and neonatal morbidity.

Design: Cross-sectional regression analysis of birth certificate records linked with hospital inpatient claims for mothers and babies, controlling for the mother's demographics and comorbidities, and using month, year, and facility fixed effects.

Setting: All hospitals providing obstetric care in Philadelphia, Pennsylvania between 1995 and 2010.

Participants: All women delivering at a Philadelphia, Pennsylvania hospital during the study period, restricted to those for whom there was adequate information to determine time on the labor floor and appropriately risk adjust analyses.

Exposure: The number of overlapping women admitted to the labor floor during the six hours prior to a woman's delivery, or during the time between admission and delivery, if this is shorter than 6 hours.

Main outcomes and measures: Primary outcomes are the incidence of interventions designed to expedite delivery (cesarean delivery, episiotomy, artificial rupture of membranes, and forceps/vacuum). Secondary outcomes are adverse maternal health outcomes (prolonged length of stay, obstetric infection, postpartum hemorrhage, and severe perineal laceration) and adverse neonatal health outcomes (birth injury, seizure, 5 minute APGAR score < 7, and NICU admission).

Results: There were 289,788 cases where adequate information was collected on the mother to identify her time on the labor floor and adequately risk adjust. Increased labor floor busyness was associated with substantial increases in the likelihood of interventions and adverse maternal health outcomes, and had no significant association with adverse neonatal health outcomes. For example, compared with cases where there were no other women on the labor floor, women on labor floors with average busyness had significantly higher risk of a cesarean delivery (odds ratio 1.12, 95% confidence interval, 1.06 – 1.17, $p<0.00$) and of postpartum hemorrhage (odds ratio 1.11, 95% confidence interval, 1.01 – 1.23, $p=0.04$).

Conclusions and relevance: Increases in short-term busyness are associated with significant risk to maternal safety. Future research should investigate whether earlier recruitment of staff, beds, and other safety-critical resources can reduce harm.

Introduction

Childbirth is the most frequently used hospital-based service in the United States and quality of care is known to vary widely at the hospital level, even after accounting for differences in patient risk.[1] For example, the rate of cesarean delivery, an intervention designed to expedite delivery when labor is deemed too risky for a mother or fetus, has been shown to vary 10-fold between 7% and 70% at the hospital level among all patients, and 15-fold among only low-risk women.[2] This variation is one of several indicators that interventions are frequently overused in these settings despite risks of complications such as hemorrhage, infection, and organ injury.[3] One explanation for this variation is the ability of the hospital to efficiently allocate staff, beds, and other resources that are critical to patient safety, particularly during short-term periods of increased busyness.[4–7]

Hospital labor and delivery units can experience large fluctuations in busyness due to high turnover in patient census. A unit that is busy with many laboring women at 10:00 pm can experience several deliveries and be relatively quiet by midnight. During periods of high busyness, safety-critical resources can be challenging to recruit quickly. Prior work has shown that busyness can lead to bottlenecks in staff and bed availability leading to delays in patient care.[4,7] Moreover, the ability to manage resources to avoid these bottlenecks has been associated with patient outcomes, including rates of cesarean delivery, hemorrhage, and neonatal injury.[6,8–10] However, prior efforts to investigate the relationship between busyness and patient safety employ limited proxies for busyness such day of the week (weekday vs weekend)[8] or daily patient volume.[10,11] A precise relationship between short-term busyness and safety for mothers and infants has not yet been demonstrated.

Recently, busyness has been examined with greater precision in surgery. The challenge of "overlapping" surgeries, a circumstance when the same surgeon oversees more than one simultaneous operation, has emerged as a significant risk factor for postoperative complications, including infection, revision, and dislocation within one year of hip surgery.[12] These findings are consistent with prior studies of busyness in a broad range of clinical contexts, including in emergency departments[13] and intensive care units[14].

Rather than relying on limited proxies for estimating busyness, we identify all patients that are simultaneously admitted to a labor and delivery unit. This identification allows us to more precisely measure "unpredictable" busyness in terms of overlapping patients. On these units, busyness creates an incentive to decrease clinical workload and relieve strained resources by using procedures that expedite delivery of the baby. We hypothesize that increased labor floor busyness may increase the use of these procedures. Due to the risks of overutilization, we additionally explore the impact of busyness on adverse maternal and neonatal outcomes.

Methods

We performed a retrospective analysis of deliveries in Philadelphia between 1995 and 2010 using three primary data sources: (1) birth certificate records, (2) medical claims records associated with obstetric deliveries for mothers, and (3) medical claims records associated with obstetric deliveries for neonates. The birth certificate records are maintained by the Pennsylvania Department of Health's Bureau of Health Statistics and Research and the claims records are maintained by the Pennsylvania Health Care Cost Containment Council (PHC4). The accuracy and validity of these datasets are verified by these relevant agencies.

We identified medical claims for mothers and neonates that were associated with deliveries using a previously established, enhanced identification method that relies on delivery-related ICD-9 codes and DRGs and is less likely to omit cases with severe complications (specific codes are detailed in the supplementary materials).[15] PHC4 merged the birth certificate records with the maternal and neonatal delivery-related medical claims databases by (1) matching on the mother's social security number and date of birth, available in both the birth certificate and claims databases, and (2) confirming that the birth certificate neonate date of birth was between the hospital admission and discharge dates, as recorded on the medical claims.

Using the dataset of merged maternal claims and birth certificate records, we first identified all cases with adequate information to determine the specific start and end times when the mother was on the labor floor (i.e., when she was admitted and when she delivered). To determine times on the labor floor, we used the date and time of birth from the birth certificate records, and the mother's length of stay (days) and hour and day of the week of admission from the medical claims records. Because the claims records do not include the date of admission (only day of the week), we excluded all cases where the mother's length of stay was 7 days or more since we then could not identify when in the hospital stay the admission specifically occurred (e.g., in a subset of cases there was information such as: length of stay: 10 days; admission day: Wednesday; delivery date: Friday, January 15, where it would not be possible to infer whether the admission occurred on Wednesday, January 6 or Wednesday, January 13). Using these cases where there was adequate information to determine time on the labor floor, we formed a 16-year census for all labor units in Philadelphia, allowing us to identify how many women were on each labor floor at any given time between January 1995 and December 2010, excluding the subset of cases where the mother had an unusually long length of stay.

We constructed two samples for this analysis: (1) the full sample of all mother-neonate cases where there was adequate information in the claims and birth certificate records to determine times on the labor floor (described above) and for whom we have adequate information to properly risk adjust (covariates are described below and in the supplementary materials), and (2) a subset of this full sample that is identified as "low risk" for a cesarean prior to delivery, as defined by AHRQ's Inpatient Quality Indicator #33, which excludes all cases with abnormal presentation, preterm, fetal death, or multiple gestation diagnosis codes, breech procedure codes, or a previous cesarean. While originally defined based on risk for a cesarean, this subset has been used in analyses of a range of maternity care outcomes.[16–18]

The primary outcomes of these analyses were the incidence of interventions designed to expedite delivery of the neonate (cesarean delivery, episiotomy, artificial rupture of membranes, and forceps/vacuum). The secondary outcomes were the incidence of adverse maternal health outcomes (prolonged length of stay, obstetric infection, postpartum hemorrhage, and severe perineal laceration) and adverse neonatal health outcomes (birth injury, seizure, 5 minute APGAR score < 7, and NICU admission). We chose these outcomes because they are commonly audited and reported for hospital quality assurance. As a falsification test, we additionally analyzed low birth weight, an outcome that would not be influenced by care at the time of delivery.

The exposure in this study is busyness, measured by the number of other "overlapping" women who were also admitted to the labor unit prior to delivery, while the index woman was admitted as well. We focused only on overlaps in the six hours prior to birth rather than the entire time the woman is on the labor floor in order to: (1) minimize potential for confounding, given that the total time between admission and delivery is positively correlated with both risk of complications and the number of overlapping women, and (2) provide a focused window that is likely to include the full duration of the second stage of labor (the period between full dilation of the cervix and delivery) for most women. During this period, nurses are generally required to be staffed one-to-one with patients and staffing resources are most strained. In cases where the woman' s time between admission and delivery was less than six hours, we focus only on the window of time that she was on the labor floor.

We used multivariable logistic regression models to evaluate the association between labor floor busyness and outcomes, controlling for maternal demographic characteristics and comorbidities that have previously been found relevant when evaluating the risk of interventions during labor and of adverse health outcomes.[19,16–18] Specifically, we included as controls in all reported specifications the mother's age; mother's race; payer/insurer; abnormal indications (diagnosis of abnormal presentation, preterm, fetal death, or multiple gestation); breech procedures; and previous cesarean. In addition to mother-specific controls, to further minimize potential confounding we included fixed effects for the facility, year, and month of birth. By including these fixed effects we are identifying off of variation in busyness within each facility within each month-year over the 16-year study period. In other words, the results from these analyses are not driven by facility-specific factors or time trends. Given that there may be non-linearity in the relationship between busyness (measured through number of overlapping women) and the analyzed outcomes, we separately included each number of overlapping women in the six hours prior to birth in the logistic regressions. As a result, the odds ratios associated with each number of overlapping women are interpreted compared to the base case of zero overlapping women (i.e., when the index case is alone on the labor floor). We used statistical software (Stata, version 14; StataCorp) for data management and analyses.

This study was approved by the Harvard University Committee on the Use of Human Subjects (IRB15-3616) under expedited review, as well as by the relevant Pennsylvania agencies (the Pennsylvania Health Care Cost Containment Council and the Pennsylvania Department of Health's Bureau of Health Statistics and Research).

Results

There were 358,452 delivery-related maternal claims records over the 16-year study period in Philadelphia. Of these PHC4 successfully matched 317,952 (88.7%) to the birth certificate records. Just under half of the unmatched cases, 16,477 (4.6% of the claims), were unmatched due to invalid social security numbers. Working from the 317,952 cases that were successfully matched, 290,169 (91.3%) had adequate information to determine the mother's time and date of admission and delivery (i.e., at what times the woman would be counted in the labor floor census), and 289,788 cases (99.9%) of these cases had adequate information for risk-adjustment and were used in the final analytical sample. Of this sample, 221,948 (76.6%) qualified as "low risk".

On the neonate side, there were 356,383 newborn discharge claims records over the study period. Of these, PHC4 successfully matched 274,879 (77.1%) to the birth certificate records. Most of the unmatched cases were due to an inability to identify the correct matching birth certificate, though 12,998 (3.6% of the claims) were not attempted due to multiple births (e.g., twins). Of the 274,879 successfully matched cases, 230,956 (84.0%) were successfully matched with a maternal record with adequate information to determine times on the labor floor, and 228,441 (98.9%) of these had adequate risk adjustment information to be included in the main analyses. Of this sample, 177,008 (77.5%) qualified as "low risk".

Overall, there was an average of four additional overlapping women on the labor floor in the six hours prior to delivery for the index woman (i.e., five women in total). The full distribution of the number of overlapping women in the six hours prior to birth is shown in the supplementary materials (Figure 1). The distribution is right skewed; the median is 3 overlaps and the 90th percentile is 8 overlaps.

Key demographic and clinical characteristics are similar across different degrees of exposure to busyness (Table 1). Women across the groups averaged about 26 years old; the most common racial groups were "Black alone" (44.0%) and "White alone" (29.0%); and the most common payers were Medicaid (47.5%), Blue Cross (24.0%), and a commercial employer (20.8%). Most women did not have any of the three "high risk" characteristics of abnormal indications, breech procedures, or a previous cesarean. On average, the group had an average cesarean section rate of 25.1%, ranging from 22.0% in the group with 0-1 overlapping women to 28.9% in the group with 6 or more overlapping women.

The degree of busyness on the labor floor was significantly associated with an increased likelihood of interventions. Figure 1 shows the odds ratios, with 95% confidence intervals, of cesarean delivery, episiotomy, artificial rupture of membranes, and forceps/vacuum for each number of overlapping women, compared with 0 overlaps (i.e., when the mother is the only one on the labor floor in the six hours prior to delivery or time between admission and delivery, if this time is less than 6 hours) and controlling for patient characteristics and the facility, month, and year. Women on labor floors with average busyness had a significantly higher risk of a cesarean delivery (odds ratio 1.12, 95% confidence interval 1.06 – 1.17, $p<0.00$), episiotomy (odds ratio 1.18, 95% confidence interval 1.12 – 1.25, $p<0.00$), artificial rupture of membranes (odds ratio 1.06, 95% confidence interval 1.00 – 1.12 , $p=0.04$), and use of forceps or vacuum (odds ratio 1.36, 95% confidence interval 1.27 – 1.45, $p<0.00$). Reaching the 90th percentile of busyness (8 overlapping women) was associated with higher risks of interventional procedures

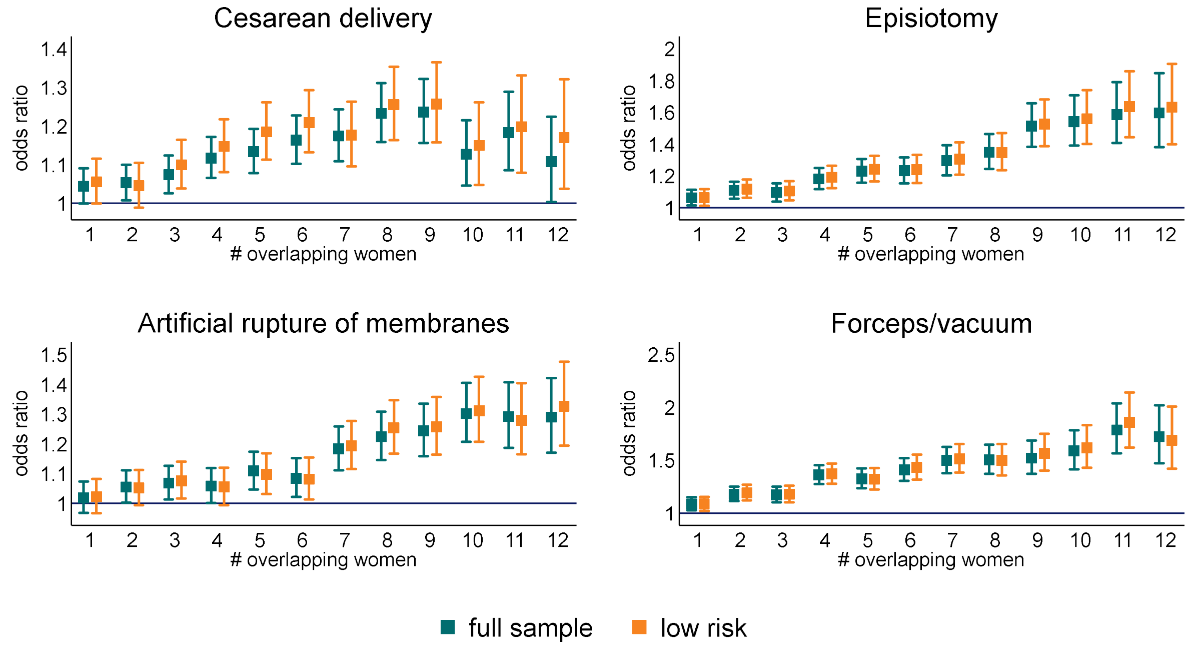
Table 1

Demographic characteristics of births, stratified by busyness

	Overall	0-1 overlapping women	2-3 overlapping women	4-5 overlapping women	6+ overlapping women
Mother's age (years)	26.64	26.31	26.29	26.49	27.42
Mother's race(%)					
Asian alone	3.63	3.87	3.65	3.56	3.44
Black alone	44.02	39.54	45.84	42.65	42.97
American Indian or Alaskan Native alone	0.25	0.21	0.29	0.29	0.22
Other	7.99	11.29	8.69	6.93	5.32
Unknown	15.13	10.98	13.35	17.13	18.94
White alone	28.96	34.08	28.17	24.42	29.1
Miscode	0.01	0.02	0.02	0.01	0.00
Abnormal indications (%)	12.23	11.40	12.11	12.82	12.59
Breech procedures (%)	0.15	0.15	0.19	0.14	0.11
Previous cesarean (%)	12.79	11.73	12.59	12.88	13.83
Payer (%)					
Self-pay	0.67	0.81	0.71	0.67	0.50
Medicare	1.12	0.47	0.66	1.04	2.23
Medicaid	47.45	43.10	48.31	51.86	46.67
Blue Cross	23.99	21.11	21.67	23.13	29.56
Commercial employer	20.78	23.53	21.62	18.96	19.00
Government	0.45	0.44	0.43	0.44	0.49
Unknown	5.55	10.53	6.61	3.90	1.54
Cesarean delivery (%)	25.12	22.00	23.62	25.63	28.94
N	290,157	65,972	83,443	62,486	78,256

Notes: Overlapping women are defined as the number of other women on the labor floor between the index woman's time of delivery and the previous six hours, or between the index woman's time of arrival and time of delivery, whichever is shorter. Abnormal indications are defined by abnormal presentation, preterm, fetal death, and multiple gestation. ICD-9 codes associated with abnormal indications, breech procedures, and previous cesarean are defined in the supplementary materials.

Figure 1: Association between busyness and interventional procedures



Notes: the odds ratios comparing each number of overlapping women, in the six hours prior to birth, to zero overlapping women, adjusted for key covariates, are shown with 95% confidence intervals. The dark/blue squares show the odds ratios for the full sample; the light/orange squares show the odds ratios for the ex-ante "low risk" subsample (defined in the supplementary materials). Outcomes and covariates are measured using claims and birth certificate data; specific definitions are described in the supplementary materials. Analyses of episiotomy and forceps/vacuum are restricted to cases of vaginal delivery.

(e.g., cesarean delivery odds ratio 1.23, 95% confidence interval 1.16 – 1.31, $p<0.00$). In general, the magnitude of the relationship was slightly larger or equal for the "low risk" subgroup.

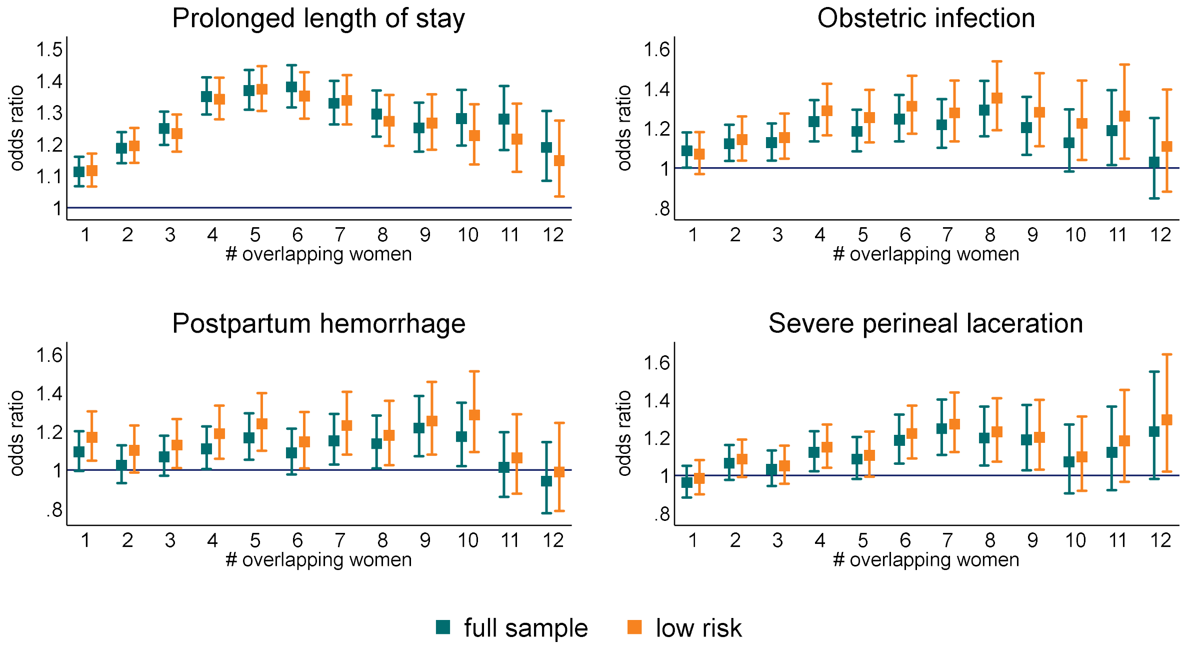
Busyness on the labor floor is also associated with worse maternal health outcomes. Figure 2 shows that women on labor floors with average busyness had a significantly higher risk of prolonged length of stay (odds ratio 1.35, 95% confidence interval 1.29 – 1.41, $p<0.00$), obstetric infection (odds ratio 1.23, 95% confidence interval 1.13 – 1.34, $p<0.00$), postpartum hemorrhage (odds ratio 1.11, 95% confidence interval 1.01 – 1.23, $p=0.04$), and severe perineal laceration (odds ratio 1.12, 95% confidence interval 1.02 – 1.23, $p=0.02$). The magnitudes of these associations are similar in the low risk subset. Conversely, Figure 3 shows there is no consistent relationship between busyness and neonatal health outcomes; it does not appear that neonates born during busier times are more likely to experience birth injury, seizure, 5 minute APGAR < 7, or a NICU admission. Finally, Figure 2 in the supplementary materials shows that there is no relationship between busyness and low birth weight.

Discussion

We show that short-term busyness on labor and delivery units is associated with a higher risk of interventions and of adverse maternal outcomes, while having no measurable impact on the neonate. These effects hold even while controlling for numerous maternal and facility characteristics, as well as time trends. Our subsample analyses of low risk deliveries demonstrate that these effects are common across a range of cases. Our falsification test, showing no impacts on an outcome that should not be influenced by care at the time of delivery, provides evidence of the reliability of the analytical approach.

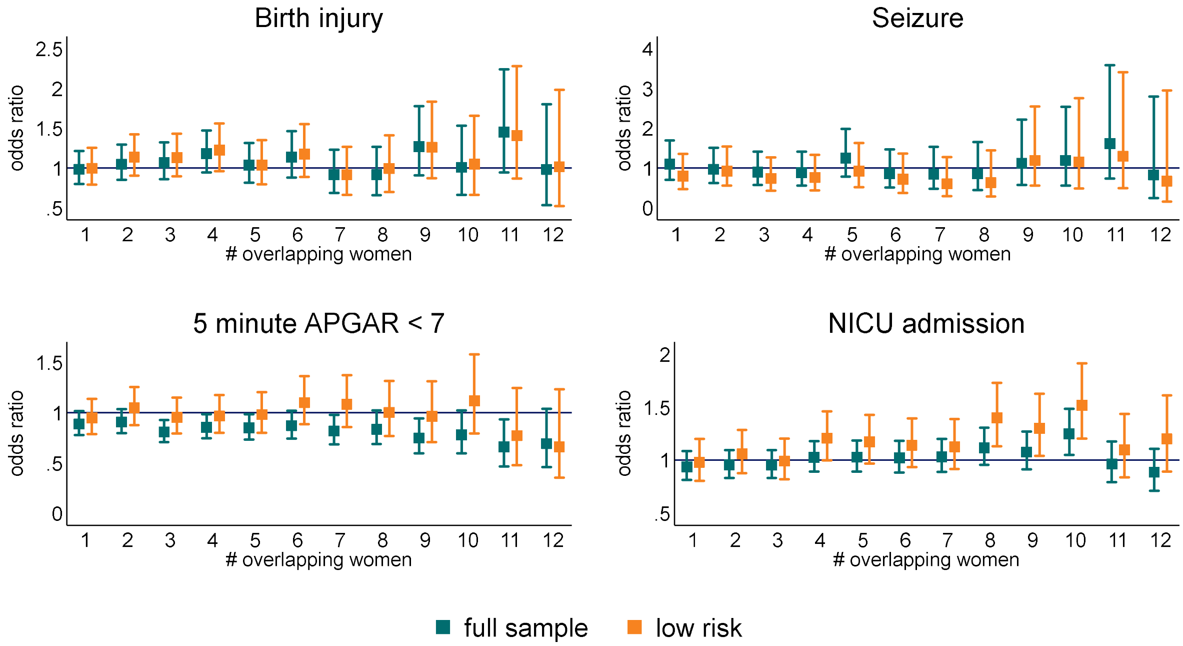
Interventions to expedite delivery, particularly cesarean deliveries, are often performed with the aim of protecting the neonate. However, there were no associated improvements in

Figure 2: Association between busyness and maternal health outcomes



Notes: the odds ratios comparing each number of overlapping women, in the six hours prior to birth, to zero overlapping women, adjusted for key covariates, are shown with 95% confidence intervals. The dark/blue squares show the odds ratios for the full sample; the light/orange squares show the odds ratios for the ex-ante "low risk" subsample (defined in the supplementary materials). Outcomes and covariates are measured using claims and birth certificate data; specific definitions are described in the supplementary materials.

Figure 3: Association between busyness and neonatal health outcomes



Notes: the odds ratios comparing each number of overlapping women, in the six hours prior to birth, to zero overlapping women, adjusted for key covariates, are shown with 95% confidence intervals. The dark/blue squares show the odds ratios for the full sample; the light/orange squares show the odds ratios for the ex-ante "low risk" subsample (defined in the supplementary materials). Outcomes and covariates are measured using claims and birth certificate data; specific definitions are described in the supplementary materials.

neonatal morbidity, suggesting that increases in cesareans and other childbirth interventions that are inherently risky to the mother were not offset by reductions in rates of adverse neonatal outcomes.

A number of past studies have attempted to analyze the impact of busyness on patient care, including in the context of maternity care where significant fluctuations in the patient census are common.[19,11,10] These studies' findings have been inconsistent, partially because they have used proxy measures of busyness such as daily volume that may instead measure general busyness that is relatively predictable and therefore relatively easy for the unit to adapt to. By leveraging a novel identification strategy and a robust dataset combining multiple administrative records, we were able to measure this relationship with greater precision.

There are multiple potential underlying mechanisms that could explain our findings. It could be that providers consciously make a decision to perform a cesarean during times of high patient census to free up a labor floor bed. Alternatively, it could be that providers make different decisions under cognitively overloaded conditions (e.g., assessing a marginal case as necessary for a cesarean, or failing to note the severity of potential warning signs). It is also plausible that differences in use of procedures and in the health outcomes we observed have different mechanisms. For example, some effects on the use of interventions may be driven by the need to accelerate bed turnover, while some effects on health outcomes may be driven by provider neglect or wait times for key resources.

This study has some important limitations. First, we do not have information about what specific management strategies were available to the hospitals to respond to short-term fluctuations in labor floor busyness, including policies around staffing, beds, or diversion. Better understanding of these policies would allow for a more nuanced interpretation of the findings.

For example, if increasing staff during busy times is not effective, other limitations such as beds may be more relevant. Second, our sample only includes births that occurred in Philadelphia, Pennsylvania – this allowed us to analyze a relatively long period of time across a fairly large number of hospitals, but may also have implications for generalizability to other regions, particularly those that are not urban with a relatively high density of hospitals. Third, our analytical sample only included women who were admitted to the hospital for delivery. Antepartum women who had been admitted with complications and those who went through triage but were not admitted all contribute to the overall workload and resource strain on the labor ward, but are not identifiable with our dataset. While this likely introduces some noise, it is unlikely to bias these results since we include controls for the individual hospital, and policies around admission for these cases is likely to vary by hospital. Finally, the time when women are admitted to the labor floor is not random; in general, women are more likely to be admitted later in their labor process to busier labor floors, though this effect most likely biases our results downwards since the busiest times are likely underestimated by our exposure measure.

A better understanding of the specific underlying mechanisms driving our findings will be essential for adequately responding to them. In sensitivity analyses, we found that the number of overlapping women is more strongly associated with interventions and adverse health outcomes than a measure of remaining beds open on the labor floor, providing suggestive evidence that limitations in staffing resources are more important than limitations in bed availability. Additionally, it does not appear that the relationship between busyness and adverse maternal health outcomes is driven primarily by the increased likelihood of interventional procedures, as controlling for the use of these procedures does not have a strong effect on the observed relationship with adverse maternal health outcomes.

Conclusions

Increasing busyness on the labor floor appears to increase the risk to maternal health. Future research should investigate the specific underlying factors driving this relationship and investigate whether earlier recruitment of safety-critical resources can reduce harm.

Funding

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Chapter 2: Behavioral nudges toward increased consumption of improved maize by young children: a cluster randomized experiment in Ethiopia

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Abstract

Background: Improved crop varieties have potential to improve childhood nutrition in agricultural communities, but their introduction has not yet translated into meaningful nutritional gains. We tested the impact of a child consumption targeting intervention package in rural Ethiopia.

Methods: We conducted a non-blinded, cluster randomized trial in 12 rural, maize-growing kebeles of Oromia, Ethiopia. Clusters of households were stratified by kebele and then randomized between a basic treatment where an improved maize variety, Quality Protein Maize (QPM), was offered (320 households, 203 clusters), and a QPM + targeting intervention focused on increasing young children's QPM consumption (290 households, 183 clusters). Households were eligible if they had a child who was 6-35 months old at the time of the baseline survey in August 2015 (the "index child") and had chosen to plant QPM in May-June 2015, after the QPM was offered. In the QPM + targeting clusters, household heads and caregivers for the index children were given specific instructions about the importance of feeding QPM to the index child and tools to help them label and earmark the grain and flour for child consumption and cook specifically for the index child. 304 households in the QPM only group and 266 households in the QPM + targeting group were evaluated at 6 and 10 months post intervention. The primary outcomes were the index child's QPM consumption and anthropometric measures for the index child (weight-for-age, height-for-age, based on WHO growth standards). Secondary outcomes included QPM storage, whether QPM had been reserved for home consumption, and cooking specifically for the index child. Impacts were estimated using intention-to-treat analyses.

Results: The intervention package was associated with a 17 percentage point increase in the probability of the index child consuming QPM in the previous week (95% CI 9 to 25), and an average increase in days QPM was consumed in the past week of 0.83 days (95% CI 0.33 to 1.33). There were, however, no positive impacts on anthropometric outcomes such as height-for-age and weight-for-age z-scores. Six months after the consumption targeting intervention began, households that received the intervention package were more likely to store QPM separately, increase days in the past week QPM was cooked for the index child, and differentially increase the index child's QPM consumption compared to the household head. These effects were attenuated, but generally persisted, at 10 months post-intervention.

Conclusions: In settings like Ethiopia, child consumption targeting campaigns focused on improved crop varieties that use behavioral nudges such as labeling and earmarking appear to be effective at changing food consumption and cooking behaviors. These changes did not, however, translate into improvements in child anthropometrics, possibly given the short time frame of the study.

Introduction

Undernutrition is the underlying cause of 3.1 million child deaths each year.[1] In Ethiopia, nearly two fifths of children meet the qualifications for stunting (height-for-age z-score below -2),[2] which is associated with poor health outcomes such as reduced cognitive and motor development.[3] Malnutrition is associated with a loss of $4.7 billion each year in the country, about 16.5% of GDP.[4] In order to address the adverse consequences of malnutrition, several international and national organizations have set ambitious targets, including a reduction by 40 percent of the number of stunted children by 2025, and ending all forms of malnutrition by 2030.[5, 6]

Poor dietary quality is an important cause of malnutrition, and is particularly prevalent in Ethiopia. For example, recent data suggest that only 7% of Ethiopian children 6-23 months old meet the requirements for the WHO's definition of a minimum acceptable diet, a measure of the diversity and frequency of food consumption.[2] Given the importance of agriculture for much of Ethiopia and other developing countries, improved crop varieties (e.g., with improved protein quality) have been proposed as one means of improving children's dietary quality and reducing child malnutrition rates. While agronomists have successfully developed a number of these improved crop varieties, take-up and, particularly, consumption by young children have been low. There are several reasons for this low take-up in Ethiopia and elsewhere, including (1) experimenting with new crop varieties is risky and difficult for households given the importance of agricultural production for the household's income and own consumption, (2) changing cooking behaviors is difficult, even when there are clear benefits for some or all of the household[7], (3) much of current agricultural extension and education efforts are not directed at women, who typically manage feeding for young children, and (4) targeting the improved varieties to young children requires households to keep the improved crops separate from conventional ones at all stages of production, harvest, post-harvest handling, storage, milling, cooking, and consumption.

In this paper we report the results of a study designed to test behavioral techniques for improving targeting of improved crop varieties to young children among households that have opted to experiment with planting the new varieties. We focus on maize, which is the primary cereal consumed by Ethiopians.[8] The targeting interventions primarily consisted of the provision of maize earmarking tools for storing and feeding that were labeled for consumption by the household's young children. These interventions were motivated by research in financial contexts, which has shown that small nudges, including labeling or earmarking tools, can induce substantial behavior changes.[9, 10] The goal of this study was to estimate the impact of a package of targeted consumption interventions on children's consumption of the improved maize variety and nutritional status; household cooking practices; and household storage and management of the improved maize variety. Findings from this study will help inform future policy to drive behavior change in nutrition interventions.

Methods

Study population and setting

The study took place in the East Wollega and Jimma zones of the Oromia region of Ethiopia between April 2015 and June 2016. About 90% of the population in Oromia is engaged in agriculture, and household food needs are largely met through home production. Maize has become increasingly important both as a crop, with its share of cereal production reaching one third[11], and as a food source, with current consumption reaching 44 kg per person per year.[8] The quality of children's diets in rural Ethiopia is poor; only 6% of children 6-23 months old had diets that met the requirements for a "minimum acceptable diet", an indicator measuring the diversity and frequency of food consumption. Ethiopian households are organized into small Community Health Groups, designed to facilitate interactions with the local community health workers.

This study was based in 12 kebeles (a group of villages, the smallest administrative unit in Ethiopia). 3 to 5 months before the study took place, Nutritious Maize for Ethiopia (NuME, a project administered by the International Maize and Wheat Improvement Center, CIMMYT) conducted "demonstrations" of Quality Protein Maize (QPM). QPM refers to the set of conventionally modified (i.e., not genetically modified) maize varieties that have improved protein quality (i.e., more available protein) while maintaining other characteristics comparable with conventional maize varieties (e.g. agronomic, storage, and food preparation qualities).[12, 13] In acceptance tests in Ethiopia and other nearby countries, consumers found QPM to be equally appealing or superior to conventional maize on a range of dimensions, including aroma and taste.[14] In controlled trials, QPM has been shown to improve child growth, but its effectiveness has not been shown in real-world settings.[15] Demonstrations are where community members attend events on the land of a neighbor who was selected to plant the new maize variety to learn more about the variety from NuME representatives and observe the quality and pace of the maize growth. Two QPM varieties were suitable for the study area and demonstrated to study participants: AMH760Q and BHQPY545.[i] Prior to these demonstrations, there was little to no exposure to QPM in the study areas. During the study, QPM seed was not available through the market or other distribution channels.

[i] AMH760Q is a late-maturing, white grain and BHQPY545 is a yellow grain with intermediate maturity; both are drought tolerant.

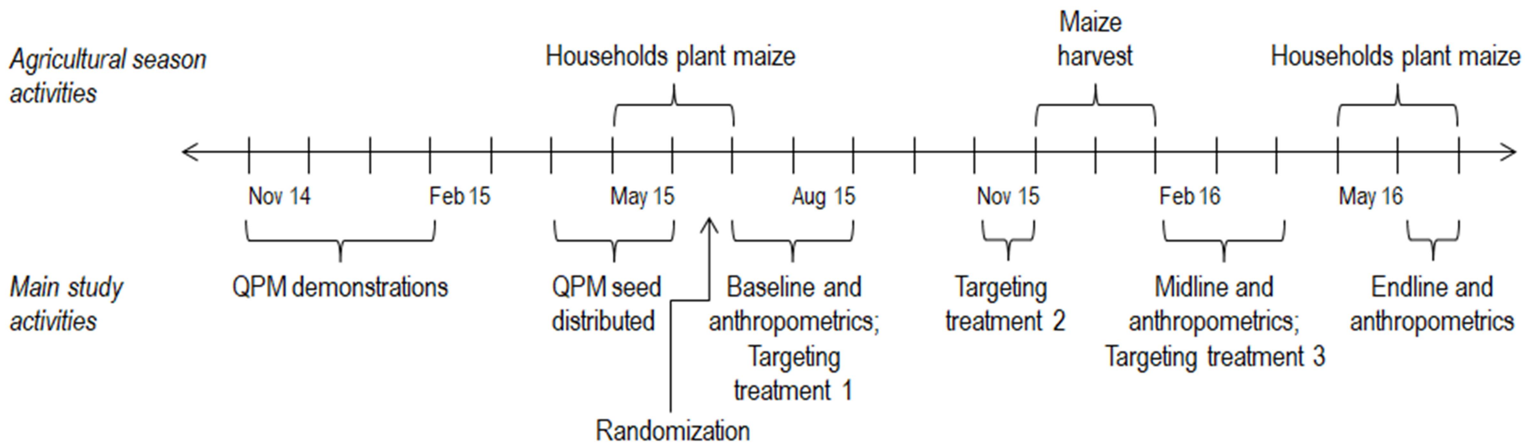
Overall study timeline and sample selection

The overall timeline of the study and relevant portions of the agricultural cycle are shown in Figure 4. There were four QPM demonstrations led by CIMMYT and Sasakawa Global 2000 between November 2014 and January 2015 in each study kebele: 1 demonstration on a Farmer Training Center plot and 3 on local farmers' plots. There were several field days over the course of the season, where community members could learn more about QPM. CIMMYT and SG2000 specifically recruited women to these events, targeting 40% participation at each field day. During these field days, CIMMYT and SG2000, with the assistance of the local DAs, described the QPM varieties and their agronomic properties. They emphasized the importance of QPM for young children and demonstrated how to cook different foods from QPM. Lists of households potentially eligible for study inclusion were created by government-employed agricultural extension workers ("Development Agents", DAs) based on whether the households attended a demonstration and whether the household had a child that would be 6-35 months old at the start of data collection. These households were then randomized into a group that would be offered QPM seed and a group that would not. The latter formed a pure control group to allow for analysis of the impact of QPM, which will be considered in other work.

The DAs then visited the households selected to receive QPM and offered the opportunity to order up to three 2 kilogram bags of QPM seed at no cost.[i] During this visit, the DAs spoke to the male household head (and primary female caregiver for the index child, if available) about the nutritional benefits of QPM consumption for young children. The development agents emphasized the nutritional benefits of QPM relative to conventional maize

[i] Note that maize seed was typically only available in 12.5 kg bags, which often resulted in farmers sharing maize seed bags since they could not use the full 12.5 kg of seed. Prior work has shown that offering farmers the opportunity to experiment with smaller amounts of seed can increase adoption rates of new varieties. (Jack, et al. 2011. Market Inefficiencies and the adoption of agricultural technologies in developing countries. ATAI White Paper.)

Figure 4: Timeline



Notes: QPM = quality protein maize; Targeting treatment 1: information about nutritional benefits of QPM and importance of keeping QPM separate during harvest and storage provided to household head, information about nutritional benefits and importance of targeting QPM provided to caregiver; Targeting treatment 2: group meetings with caregivers to discuss child nutrition and targeting and distribute labeled flour and grain bags, bowl, and spoon; Targeting treatment 3: refresher on nutritional benefits of QPM and importance of targeting provided to the caregiver just after the midline survey.

varieties and explained that children are especially vulnerable to nutritional deficiencies that QPM can help address. They also provided information about QPM planting, storage, and preparation, which are similar to traditional maize varieties. 98% of household heads expressed interest in ordering seed at these visits. Overall, households in the study ordered an average of 2.87 bags of QPM seed (i.e., 5.74 kg).

In order to receive the ordered seed, the household head went to a central location at a scheduled time about three weeks later. Households were asked not to sell or share with any other households the ordered seed. The households ordering QPM seed were prospectively randomized into a QPM only group or a QPM + targeting group. Prospective random assignment occurred prior to eligibility verification because the eligibility verification, baseline survey, and initial educational messaging for the targeting intervention all occurred during the same visit. At the time of the baseline survey, the research team visited households (July/August 2015). They first assessed eligibility for study inclusion based on the following criteria: (1) at least one member of the household attended a recent QPM demonstration; (2) the household had a child who was 6-35 months old; (3) the household had land available for crop cultivation; (4) the household had not previously grown QPM on its land; and (5) the household intended to stay in the study area for at least one year. The study focused on food targeting for children who were 6-35 months old at the start of data collection, the “index child”. If there was more than one child in a household within this age range, the younger child was chosen as the index child. The study focused on children in this age range since it excludes the period when exclusive breastfeeding is recommended (i.e., up to 6 months) and includes a critical period when children are particularly vulnerable to growth faltering due to inappropriate or inadequate complementary foods.

Eligible households were then given a baseline survey, described below, which occurred just after the time of maize planting (July/August 2015). We then returned for a midline visit 1-3 months after the maize harvest (Feb/March 2016) and an endline visit 5-6 months after the maize harvest (June 2016).

Treatment arms

The households randomized to receive the targeting treatment received the intervention in 3 stages: educational messaging on three separate occasions, plus several earmarking and labeling tools during one of these visits, as described in Figure 5. The first targeting messages were offered at the household after the baseline survey in July-August 2015 (after planting, but prior to the harvest). During this visit, enumerators reinforced the nutritional benefits of QPM and then discussed specific strategies that households could use in order to more effectively target the QPM to the household's young children. They particularly emphasized the measures that would need to be taken around the harvest time to keep the QPM separate from the rest of the household's maize. Household heads were encouraged to build separate cob storage cribs, or to partition existing storage cribs, in order to keep their QPM separate from conventional maize while it was drying. Caregivers were informed that they would be offered tools to help keep QPM grain and flour separate later in the fall.

The second stage of the targeting treatment occurred in November 2015, just before the time of the maize harvest. Caregivers in the QPM + targeting group were invited to participate in a group meeting at a nearby, central location. During this meeting enumerators used an educational poster (supplementary materials) to re-emphasize nutritional and targeting messages that had been presented earlier, and engaged participants in a group dialogue to help identify ways to better target QPM to their young children (e.g., using a separate bowl to feed the child).

Figure 5: Intervention description

	Free QPM seed	HH head basic information	HH head storage information	Caregiver storage and feeding information	Caregiver storage and feeding technology	Caregiver labeling technology
QPM only	X	X				
QPM + targeting	X	X	X	X	X	X

Free QPM seed: prior to the main agricultural season in 2015, local development agents (DA's) offered households heads up to three 2-kg bags of QPM seed to plant on their own land during the upcoming season

HH head basic information: during the DAs' visits with the household heads, they provided basic information about the benefits of QPM, particularly for young children, and information about how to maintain the improved trait during planting and harvesting; if caregivers were available, they were welcome to join for this discussion

HH head storage information: during household visits for the baseline survey in July-August 2015, enumerators spoke with household heads about the importance of keeping QPM grain and flour separate in order to be able to target the QPM to the index child, especially the importance of building a separate storage crib

Caregiver storage and feeding information: during households visits for the baseline survey in July-August 2015, enumerators spoke with caregivers about the importance of keeping QPM grain and flour separate in order to be able to target the QPM to the index child; in November 2015, caregivers participated in a group event where they discussed with enumerators and other participants how to keep QPM separate and ensure that their young children were consuming adequate amounts; in February-March 2016, after the midline survey enumerators re-emphasized informational messages that had previously been discussed

Caregiver storage and feeding technology: during group events in November 2015, enumerators distributed tools to help the caregivers keep QPM grain and flour separate and to promote effective, consistent feeding practices: 4 bags for storing QPM grain, 1 bag for storing QPM flour, 1 bowl, and 1 spoon

Caregiver labeling technology: all materials distributed during the November 2015 group visits were labeled with images of maize and of a young child consuming porridge, as well as "Quality Protein Maize" in the local language

When participants identified aspects that might be difficult such cooking separate meals for their young children, the enumerator facilitated a group discussion to help think of ways to make these challenges easier for the participants to overcome. At the end of the visit, caregivers were offered several tools to help them keep QPM grain and flour separate from other grains and flours, and to remember to do so. Each caregiver was given 4 bags for storing grain (each capable of holding 100 kg), 1 bag for storing flour (capable of holding 50 kg), and a bowl and spoon. All of these items were marked with a colorful label that had a picture of an infant eating, images of white and yellow maize, and "quality protein maize" written in the local language (supplementary materials). Additionally, each caregiver was given a smaller version of the educational poster used during the meeting. For cases where the caregiver could not attend the meeting, enumerators attempted to visit the household directly to provide similar messaging and deliver the targeting tools.

In the third and final stage of the QPM targeting intervention, the targeting messages were re-emphasized just after the midline survey in February-March 2016 (1-3 months after maize harvest). Enumerators reviewed a short set of the most important messages, focusing on the benefits of QPM consumption for young children and targeting foods made with QPM to them. The scripts for each of the three QPM targeting intervention stages are included in the supplementary materials.

Data collection

Baseline and midline surveys were conducted with both the male household head and the female primary caregiver. The endline survey was conducted with only the caregiver. Key survey modules included 7-day dietary recalls for the index child and other household members, nutrition knowledge, cooking behaviors, and QPM knowledge, storage practices, and cooking practices. Additionally, anthropometrics were collected for the index children, including height and weight. Standard anthropometric measurement techniques were used, including ensuring minimal additional clothing during weighing, re-calibrating the scale between visits, and measuring children's length/height lying down or standing depending upon age.

Randomization

Households who ordered QPM seed were randomized with equal probability into the QPM only group or the QPM + targeting group. Random assignment occurred at the community health group level and was stratified by kebele. Given the nature of the intervention, neither the study team nor participants were blinded to the study arm.

Outcomes

The primary outcomes for the study were consumption of QPM by the index child and index child anthropometrics (height- and weight-for-age z-scores). Secondary outcomes were meant to capture the pathways by which the targeting intervention could have increased index child QPM consumption and anthropometrics and included: whether QPM was stored separately from conventional maize, whether QPM was sold, whether the caregiver cooked QPM specifically for the index child, and intra-household allocation of QPM.

The index child's consumption of QPM was measured through 7-day dietary recalls (a measure of days in the past week that the child consumed QPM). Index child anthropometrics were evaluated using height-for-age and weight-for-age z-scores based on the 2006 WHO growth standards. QPM storage practice outcomes include whether the QPM grain and flour were kept separate during storage, and whether they were stored in the earmarking bags provided as part of the targeting intervention. The storage outcomes were self-reported at midline (and reflected how the QPM was previously stored if none was left during the visit) and directly observed by the enumerators at endline (only for those who had any QPM remaining). Sale of any QPM grain or flour was self-reported by the caregiver. Cooking outcomes include whether the caregiver cooked anything specifically for the young children in the household, the number of days the caregiver cooked anything specifically for the young children in the household, and these two outcomes specifically focused on QPM cooking; all cooking outcomes were self-reported. Finally, intra-household allocation of was assessed by comparing the number of days in the past week that the index child consumed QPM to the number of days in the past week that the household head consumed QPM, both reported by the caregiver during household interviews.

Statistical analysis

We first analyzed the study population at baseline, summarizing sociodemographic characteristics with percentages for categorical characteristics and mean and standard deviation for continuous variables. We then describe the implementation of the program in practice with basic descriptive analyses. Finally we conduct adjusted and unadjusted ordinary least squares regression analyses to assess the intent-to-treat impacts of the intervention package, assuming clustering at the one-to-five group level. (In the supplementary materials, we report relevant outcomes using Poisson and logistic regression models for count and binary outcomes, respectively.) For the index child's QPM consumption, we additionally analyzed the full distribution of consumption from 0 to 7 days of consumption in the past week. Adjusted analyses include controls for a range of household, caregiver, index child, health seeking, and cooking baseline characteristics, listed in the supplementary materials. All analyses were conducted using the statistical software package, Stata (StataCorp. Stata Statistical Software: Release 14. College Station,TX: StataCorp LP, 2015). Prior to the collection of any post-treatment data, the primary and secondary outcomes for this trial were registered on clinicaltrials.gov and the American Economic Review's RCT Registry, numbers NCT02710760 and AEARCTR-0000786, respectively.

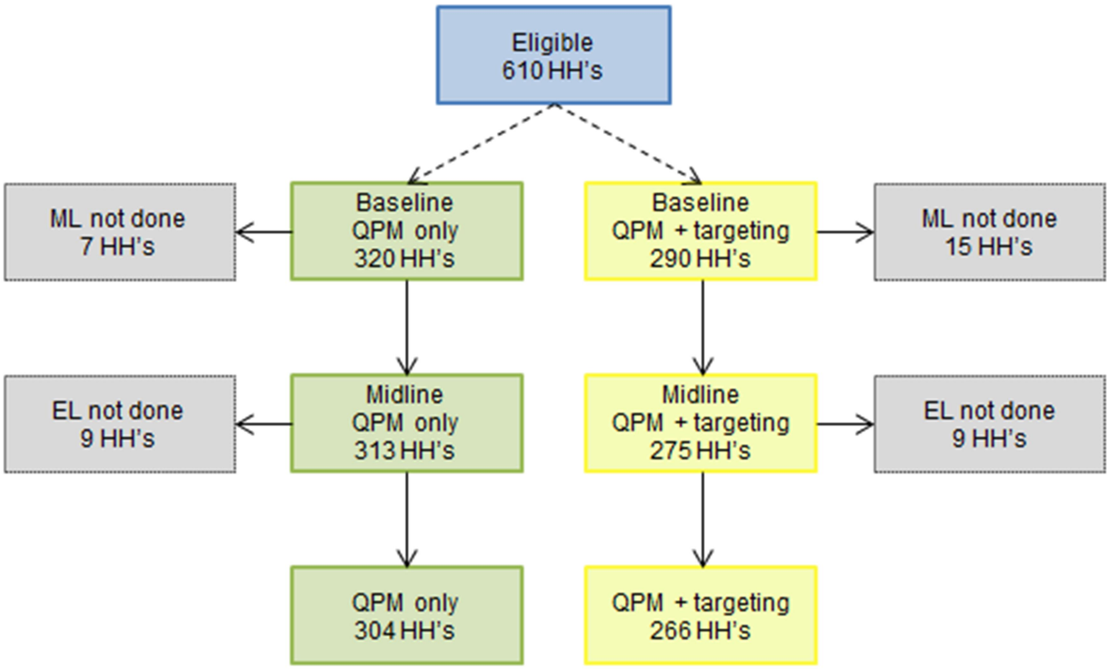
Results

There were 1,024 households listed by Development Agents as potentially eligible for the study. 511 households were randomly assigned to the QPM only group and 513 randomly assigned to the QPM + targeting group. After assessing study eligibility, there were 320 households in the QPM only group (203 clusters) and 290 households (183 clusters) in the QPM + targeting group. Among these, 304 QPM only households (195 clusters) and 266 QPM + targeting households (174 clusters) were successfully reached for all three rounds of data collection and included in the final study sample considered in all analyses below. See Figure 6 for more details on study flow.

Of the 266 households in the final sample that were assigned to the QPM targeting intervention, 220 (83%) attended one of the QPM targeting group presentations and discussions (as part of stage 2 treatment activities). An additional 28 (11%) did not attend a QPM targeting group event, but were reached in their own homes and received the messaging and tools that were distributed during the group event. The remaining 18 households did not participate in the intervention, due to ineligibility, moving, child death, or not planting/receiving any QPM seed.

On average study households had just over 6 members, about 5.5 timad (1.4 hectares), and produced around 2,000 kg of maize in the previous main growing season. The caregivers averaged about 28 years old, with about a third having ever attended school. Index children's diet primarily consisted of conventional maize-based products, with little QPM consumption. The children's nutritional status was generally poor, with average height-for-age and weight-for-age z-scores of -1.36 and -0.99, respectively. Overall, households in the two arms have similar

Figure 6: Consort diagram



Notes: dashed lines correspond to random assignment; HH = household, QPM = Quality Protein Maize.

socioeconomic characteristics, cooking and feeding practices, and health and health seeking behavior (Table 2). Nonetheless there are significant differences across arms in the characteristics of the index children including age, sex, and anthropometrics.

Figure 7 shows the histogram of the index child's 7-day QPM consumption for both study arms at midline (Panel A) and endline (Panel B). In the QPM only group at midline, 37% of index children consumed no QPM over the previous 7 days. The targeting treatment reduced the share of children with zero QPM consumption over the past week to 18%. Consumption of QPM is higher at each non-zero point in the distribution in the targeting group at midline; for example, there is an increase in the share consuming QPM every day of the week from 39 to 45% at midline. Effects of the intervention are attenuated at endline (Panel B), although the targeting treatment reduces the share not consuming any QPM from 49% to 42%.

Table 3 provides additional analysis of the index child's food consumption. At midline (Panel A), the targeting interventions increased QPM consumption by 0.83 extra days per week (95% CI 0.33 to 1.33). There were also significant effects on the index children's consumption of porridge, injera, quita, and dabo made with QPM, generally increasing the child's consumption of these foods by about 0.5 days, translating into 21 to 62% increases compared to the QPM only group. Index children in the QPM + targeting group consumed conventional maize 0.39 (95% CI -0.92 to 0.14) fewer days than children in the QPM only group. The treatment effects largely dissipate by endline (Panel B); they are no longer as large in magnitude nor statistically significant. Adjusted and unadjusted estimates are largely consistent for both midline and endline.

Anthropometric outcomes are presented in Table 4. No statistically significant changes in HAZ or WAZ across arms are found at either midline or endline.

Table 2 Baseline characteristics of the study participants

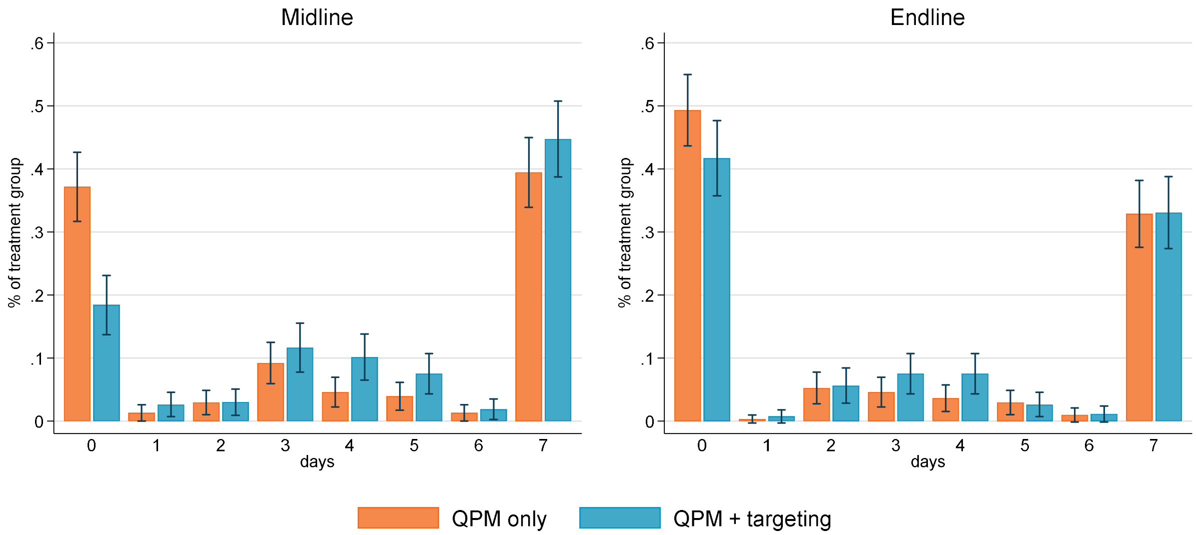
	QPM only Final sample (n=304)	QPM + targeting Final sample (n=266)	p-value
Household characteristics			
Number of household members	6.24 (1.96)	6.20 (2.11)	0.99
High quality roof*	0.61 (0.49)	0.53 (0.50)	0.09
Land owned (timad)*	5.62 (6.62)	5.48 (5.99)	0.64
Maize produced (kg)*	1719.27 (2342.59)	2042.40 (2438.58)	0.45
Caregiver characteristics			
Age (years)	28.54 (5.67)	28.36 (5.99)	0.82
Attended school	0.30 (0.46)	0.38 (0.49)	0.07
Number of pregnancies	4.48 (2.14)	4.38 (2.38)	0.79
Index child characteristics			
Age (months)	19.06 (7.89)	20.75 (8.91)	0.02
Male	0.56 (0.50)	0.47 (0.50)	0.06
Height-for-age (z-score)	-1.47 (1.36)	-1.22 (1.51)	0.04
Weight-for-age (z-score)	-1.06 (1.09)	-0.90 (1.16)	0.12
Health and health-seeking behavior			
Index child sick with diarrhea in past 2 weeks	0.19 (0.39)	0.15 (0.36)	0.32
Index child sick with cough/breathing problems in past 2 weeks	0.18 (0.38)	0.14 (0.35)	0.16
Index child sick with fever in past 2 weeks	0.20 (0.40)	0.18 (0.38)	0.29
Number times CG sought ANC during pregnancy with index child	3.22 (1.65)	3.23 (1.49)	0.93
Cooking & feeding			
Days in past week cooked specifically for young child	1.82 (2.24)	1.77 (2.31)	0.94
Days in past week cooked something with maize	5.66 (2.50)	5.72 (2.42)	0.98
Days in past week cooked something with QPM	0.12 (0.73)	0.25 (1.12)	0.14
Days in past week index child ate something with QPM	0.12 (0.73)	0.18 (0.87)	0.57
Days in past week cooked porridge and served to young child	0.78 (1.24)	0.78 (1.22)	0.43

Table 2 (continued)

Days in past week served fruit to young child	1.38 (1.68)	1.23 (1.76)	0.37
Months exclusively breastfed index child	5.22 (1.67)	5.07 (1.43)	0.46
Worried not enough food because not enough money, in last 3 mos.	0.40 (0.49)	0.35 (0.48)	0.21
Attrition	0.05 (0.22)	0.08 (0.28)	0.16
Joint test of orthogonality F-statistic		2.21	0.00

Notes: The final sample is defined as all households where the caregiver survey was conducted at baseline, midline, and endline. Means and standard deviations for each outcome are shown. P-values are derived from a regression of the outcome on an indicator for the QPM + targeting group, controlling for kebele (strata) and clustered at the 5 to 1 group level. Child height-for-age and weight-for age z-scores are normalized using the 2006 WHO growth standards. The joint test of orthogonality is a test of the null hypothesis that the coefficients on all characteristics in the table are jointly equal to zero, where the outcome is an indicator for the QPM + targeting group. *rows are measured through the household head survey, QPM only n = 303, QPM + targeting n = 261.

Figure 7



Notes: QPM = Quality Protein Maize. The left panel shows the distribution of number of days in the past week that caregivers reported the index child consuming foods with QPM at midline; the right panel shows the same at endline. Error bars are calculated using standard deviations and assuming a student's *t* distribution. Underlying numbers are shown in Table 2 of the supplementary materials.

Table 3 Impact of the intervention package on consumption outcomes at midline and endline

	Mean at midline (SD)	Unadjusted		Adjusted	
		Beta (95% CI)	**p-value**	**Beta (95% CI)**	**p-value**
QPM					
Index child consumed any QPM in last 7 days					
QPM only	0.63 (0.48)				
QPM + targeting	0.82 (0.39)	0.19 (0.12 to 0.26)	0.00	0.17 (0.09 to 0.25)	0.00
Days index child consumed QPM last week					
QPM only	3.57 (3.13)				
QPM + targeting	4.46 (2.72)	0.96 (0.49 to 1.43)	0.00	0.83 (0.33 to 1.33)	0.00
Days index child consumed porridge with QPM last week					
QPM only	0.63 (1.09)				
QPM + targeting	1.15 (1.26)	0.54 (0.35 to 0.72)	0.00	0.41 (0.22 to 0.61)	0.00
Days index child consumed injera with QPM last week					
QPM only	2.66 (3.04)				
QPM + targeting	3.19 (3.03)	0.56 (0.07 to 1.05)	0.02	0.50 (-0.04 to 1.04)	0.07
Days index child consumed quita with QPM last week					
QPM only	1.01 (1.63)				
QPM + targeting	1.47 (1.82)	0.51 (0.22 to 0.81)	0.00	0.57 (0.24 to 0.91)	0.00
Days index child consumed dabo with QPM last week					
QPM only	1.51 (2.01)				
QPM + targeting	1.91 (1.96)	0.43 (0.09 to 0.76)	0.01	0.33 (-0.04 to 0.70)	0.08
Conventional maize					
Days index child consumed conventional maize last week					
QPM only	4.59 (3.01)				
QPM + targeting	4.22 (3.00)	-0.45 (-0.94 to 0.04)	0.07	-0.39 (-0.92 to 0.14)	0.15

Table 3 (continued)

	Mean at endline (SD)	Unadjusted Beta (95% CI)	Unadjusted p-value	Adjusted Beta (95% CI)	Adjusted p-value
QPM					
Index child consumed any QPM in last 7 days					
QPM only	0.51 (0.50)				
QPM + targeting	0.58 (0.49)	0.08 (-0.01 to 0.16)	0.07	0.02 (-0.07 to 0.11)	0.60
Days index child consumed QPM last week					
QPM only	2.90 (3.17)				
QPM + targeting	3.16 (3.07)	0.30 (-0.24 to 0.83)	0.28	0.02 (-0.53 to 0.58)	0.93
Conventional maize					
Days index child consumed conventional maize last week					
QPM only	5.14 (2.79)				
QPM + targeting	4.90 (2.85)	-0.28 (-0.75 to 0.19)	0.24	-0.13 (-0.63 to 0.38)	0.62

Notes: SD = standard deviation; CI = confidence interval; QPM = Quality Protein Maize; coefficients from ordinary least squares models are reported; unadjusted columns control for kebele (randomization strata) and are clustered at the 5 to 1 group level. Adjusted columns additionally control for all variables shown in Table 2 and whether the caregiver was present during the adoption encouragement, whether the household had a telephone number, and the size of the household's cluster (characteristics balanced during randomization).

Table 4 Impact of the intervention package on anthropometrics outcomes at midline and endline

	Average change between BL and ML (SD)	Unadjusted Beta (95% CI)	Unadjusted p-value	Adjusted Beta (95% CI)	Adjusted p-value
HAZ					
QPM only	-0.03 (0.72)				
QPM + targeting	-0.13 (0.81)	0.16 (-0.06 to 0.39)	0.15	-0.09 (-0.20 to 0.02)	0.12
WAZ					
QPM only	-0.10 (0.55)				
QPM + targeting	-0.15 (0.65)	0.11 (-0.07 to 0.29)	0.23	-0.03 (-0.13 to 0.07)	0.56

	Average change between BL and EL (SD)	Unadjusted Beta (95% CI)	Unadjusted p-value	Adjusted Beta (95% CI)	Adjusted p-value
HAZ					
QPM only	-0.28 (0.86)				
QPM + targeting	-0.31 (0.89)	0.18 (-0.02 to 0.38)	0.08	-0.03 (-0.14 to 0.07)	0.52
WAZ					
QPM only	-0.03 (0.67)				
QPM + targeting	-0.10 (0.73)	0.06 (-0.12 to 0.23)	0.53	-0.05 (-0.16 to 0.06)	0.39

Notes: BL = baseline; ML = midline; EL = endline; SD = standard deviation; CI = confidence interval; child height-for-age (HAZ) and weight-for age (WAZ) z-scores are normalized using the 2006 WHO growth standards; coefficients from ordinary least squares models are reported; unadjusted columns control for kebele (randomization strata) and are clustered at the 5 to 1 group level. Adjusted columns additionally control for all variables shown in Table 2 and whether the caregiver was present during the adoption encouragement, whether the household had a telephone number, and the size of the household's cluster (characteristics balanced during randomization).

Table 5 presents the impact of the intervention on intermediate outcomes such as QPM storage and cooking. The targeting interventions increased the probability that QPM grain and flour are stored separately from other grains and flours by 40 and 47 percentage points at midline (95% CI 0.32 to 0.47, 0.39 to 0.55) and 22 and 30 percentage points at endline (95% CI 0.13 to 0.31, 0.20 to 0.39). Additionally, at midline the targeting interventions increased the number of days in the past week that caregivers cooked specifically for young children by 0.22 days (95% CI -0.07 to 0.51) and the number of days in the past week that they cooked QPM-based foods specifically for young children by 0.55 days (95% CI 0.31 to 0.79). The difference in number of days in the past week that the index child consumed QPM compared to the household head increased by 1.13 days (95% CI 0.21 to 2.05). By endline, the effects on cooking behaviors had somewhat dissipated.

Discussion

Improved crop varieties have been touted as an effective, sustainable approach to improving child nutrition in developing countries, and are a key part of the Ethiopian government's plans for reaching targeted improvements in child nutrition. This approach recognizes the importance of agriculture in much of Ethiopian society, but there has been little evidence, both domestically and globally, of effective means for leveraging agriculture to improve nutrition and health.[12] This study is one of the first to examine the potential for nudges to induce relevant behavioral changes around QPM production, storage, and cooking to induce greater targeting of QPM to young children. Findings from the QPM only group from this study show that even with the free introduction of a biofortified crop and some basic education around it, targeted individuals (i.e., children) are unlikely to see a substantial benefit through changed

Table 5A Impact of the intervention package on cooking, storage, etc. outcomes at midline

	Mean at midline (SD)	Unadjusted Beta (95% CI)	Unadjusted p-value	Adjusted Beta (95% CI)	Adjusted p-value
QPM storage and utilization					
QPM grain unmixed during storage*					
QPM only	0.40 (0.49)				
QPM + targeting	0.83 (0.38)	0.43 (0.35 to 0.50)	0.00	0.40 (0.32 to 0.47)	0.00
QPM flour unmixed during storage*					
QPM only	0.26 (0.44)				
QPM + targeting	0.74 (0.44)	0.48 (0.40 to 0.56)	0.00	0.47 (0.39 to 0.55)	0.00
Own QPM left					
QPM only	0.86 (0.35)				
QPM + targeting	0.92 (0.27)	0.05 (0.00 to 0.11)	0.04	0.03 (-0.03 to 0.08)	0.34
Not sold QPM since beginning of season					
QPM only	0.92 (0.27)				
QPM + targeting	0.95 (0.22)	0.04 (0.01 to 0.08)	0.03	0.05 (0.01 to 0.09)	0.03
QPM cooking and consumption					
Cooked food specifically for young children					
QPM only	0.28 (0.45)				
QPM + targeting	0.33 (0.47)	0.05 (-0.02 to 0.13)	0.16	0.05 (-0.03 to 0.13)	0.19
Days cooked food specifically for young children					
QPM only	0.77 (1.52)				
QPM + targeting	1.08 (1.89)	0.30 (0.03 to 0.57)	0.03	0.22 (-0.07 to 0.51)	0.13
Cooked QPM food specifically for young children					
QPM only	0.10 (0.30)				
QPM + targeting	0.25 (0.43)	0.15 (0.09 to 0.21)	0.00	0.13 (0.06 to 0.20)	0.00

Table 5A (continued)

Days cooked QPM food specifically for young children					
QPM only	0.21 (0.72)				
QPM + targeting	0.85 (1.69)	0.62 (0.40 to 0.84)	0.00	0.55 (0.31 to 0.79)	0.00
Difference in number of days QPM consumed between index child and household head					
QPM only	-1.12 (5.39)				
QPM + targeting	0.08 (5.00)	1.32 (0.48 to 2.17)	0.00	1.13 (0.21 to 2.05)	0.02

Notes: *questions at midline refer to how QPM was previously stored if household had already run out of QPM at the time of the midline survey (at endline storage questions are only asked in cases where the household had QPM remaining); ^outcomes are measured at midline and endline; SD = standard deviation; CI = confidence interval; QPM = Quality Protein Maize; coefficients from ordinary least squares models are reported; unadjusted columns control for kebele (randomization strata) and are clustered at the 5 to 1 group level. Adjusted columns additionally control for all variables shown in Table 2 and whether the caregiver was present during the adoption encouragement, whether the household had a telephone number, and the size of the household's cluster (characteristics balanced during randomization). 'Difference in number of days QPM consumed between index child and household head' is equal to the number of days the index child consumed QPM minus the number of days the household head consumed QPM (i.e., a positive value indicates the index child consumed more than the household head, and vice versa).

Table 5B Impact of the intervention package on cooking, storage, etc. outcomes at endline

	Mean at endline (SD)	Unadjusted Beta (95% CI)	Unadjusted p-value	Adjusted Beta (95% CI)	Adjusted p-value
QPM storage and utilization					
QPM grain stored in intervention bag					
QPM only	0.04 (0.19)				
QPM + targeting	0.85 (0.36)	0.81 (0.75 to 0.87)	0.00	0.80 (0.73 to 0.87)	0.00
QPM flour stored in intervention bag					
QPM only	0.04 (0.19)				
QPM + targeting	0.88 (0.33)	0.83 (0.77 to 0.89)	0.00	0.82 (0.75 to 0.89)	0.00
QPM grain unmixed during storage					
QPM only	0.74 (0.44)				
QPM + targeting	0.95 (0.22)	0.21 (0.13 to 0.28)	0.00	0.22 (0.13 to 0.31)	0.00
QPM flour unmixed during storage					
QPM only	0.59 (0.49)				
QPM + targeting	0.87 (0.33)	0.28 (0.19 to 0.37)	0.00	0.30 (0.20 to 0.39)	0.00
Own QPM left					
QPM only	0.64 (0.48)				
QPM + targeting	0.69 (0.46)	0.06 (-0.02 to 0.14)	0.13	0.02 (-0.06 to 0.11)	0.57
Never sold QPM^					
QPM only	0.88 (0.32)				
QPM + targeting	0.91 (0.28)	0.05 (0.00 to 0.10)	0.04	0.05 (-0.01 to 0.11)	0.08
QPM cooking and consumption					
Cooked food specifically for young children					
QPM only	0.25 (0.44)				
QPM + targeting	0.31 (0.46)	0.07 (-0.00 to 0.14)	0.06	0.06 (-0.01 to 0.14)	0.10

Table 5B (continued)

Days cooked food specifically for young children					
QPM only	0.74 (1.51)				
QPM + targeting	0.97 (1.76)	0.25 (-0.02 to 0.52)	0.07	0.24 (-0.03 to 0.52)	0.08
Cooked QPM food specifically for young children					
QPM only	0.12 (0.32)				
QPM + targeting	0.18 (0.38)	0.07 (0.01 to 0.12)	0.02	0.03 (-0.03 to 0.09)	0.30
Days cooked QPM food specifically for young children					
QPM only	0.28 (0.90)				
QPM + targeting	0.49 (1.28)	0.21 (0.03 to 0.40)	0.02	0.16 (-0.05 to 0.37)	0.14

Notes: ^outcomes are measured at midline and endline; SD = standard deviation; CI = confidence interval; QPM = Quality Protein Maize; coefficients from ordinary least squares models are reported; unadjusted columns control for kebele (randomization strata) and are clustered at the 5 to 1 group level. Adjusted columns additionally control for all variables shown in Table 2 and whether the caregiver was present during the adoption encouragement, whether the household had a telephone number, and the size of the household's cluster (characteristics balanced during randomization). 'Difference in number of days QPM consumed between index child and household head' is equal to the number of days the index child consumed QPM minus the number of days the household head consumed QPM (i.e., a positive value indicates the index child consumed more than the household head, and vice versa).

behaviors, further evidence of the challenges of promoting adoption of improved crop varieties with the goal of improving child nutrition.

Our study showed that it is possible to elicit changes in targeted behaviors such as grain storage and targeted child feeding through behavioral nudges such as earmarking and labeling. Our primary finding that the index child's consumption of QPM increased by roughly one day per week corresponds to a nearly 25% increase in QPM consumption. Despite showing that it is possible to increase consumption and other related behaviors such as cooking and storage, this study did not demonstrate any significant impacts on child anthropometrics. There are a number of potential reasons for this, including that the increase in QPM consumption was not enough to lead to meaningful changes in growth or that the amount of time children had been eating QPM was not long enough to detect impacts. It is also possible that impurities in the QPM grain (introduced from sub-optimal planting techniques) resulted in less available protein or that measurement error in anthropometric measures reduced statistical power for detecting effects.

There are some important limitations to this study. First, many of the key outcomes of interest are self-reported and subject to response bias. However, the results around one important behavior change directly related to the behavioral components of the intervention, QPM storage, were directly observed at endline, and substantial treatment effects were present. Second, there are several conditions around this study that deviate from natural conditions, including the free distribution of QPM seed and repeated opportunities to reiterate the educational messaging. Third, there was significant imbalance in the index children's baseline anthropometrics, where the QPM + targeting group appears to have been substantially healthier and older than the QPM alone group. Finally, it is difficult to disentangle why precisely many of the treatment effects are not sustained; this is likely a combination of the behavioral effect wearing off and of running out of QPM.

The Ethiopian government has set the goal of converting 20% of the country's maize production to QPM within a few years; while this is an important first step, this study shows the importance of additional, complementary policy initiatives that will help achieve the ultimate goal of improved crops: improved nutrition.

Ethics approval

The study was been approved by Ethiopian Public Health institute Scientific and Ethical review committee (SERO-006-02-2015) and Harvard University IRB committee (IRB14-3255).

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Personalized information and labeled cash transfers to improve child nutrition: evidence from a randomized controlled trial in Ethiopia

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Abstract

Even in contexts where caregivers for young children know how to improve a child's physical growth, incorrect perceptions of a child's nutritional status may contribute toward suboptimal household choices that result in sustained child malnutrition and poor physical growth. I present here the results of a randomized controlled trial in Oromia, Ethiopia where I test how two interventions influence key behaviors including child food consumption and household food spending. Specifically I examine the effects of: (1) providing caregivers with personalized information about their young child's nutritional status (i.e., height compared to other children the same age and gender), and (2) providing caregivers with a small cash transfer, labeled for child food consumption. I find that caregivers are generally able to understand and retain information about their child's nutritional status, and this knowledge translates into small, but relevant changes in feeding, spending, and child growth. The small cash transfer labeled for the young child's food consumption induced substantially larger and wider-ranging improvements on key outcomes around the quality of the child's food consumption and household spending behaviors. There is little evidence of complementary effects of the two interventions when they are combined.

Introduction

Childhood malnutrition is a serious problem in many low-income countries, and accounts for nearly half of child deaths worldwide.[1, 2] Children who are well-nourished are better able to learn in school and grow into more physically capable adults, allowing them to be more productive in the long run. Well-nourished children also typically require less health care during childhood and adulthood, further reducing the chances of poverty for them and their families.[3]

Given the benefits of reduced childhood malnutrition, the international community has set the ambitious targets of reducing by 40 percent the number of stunted[i] children by 2025, and ending all forms of malnutrition by 2030.[4, 5] Rising national incomes will contribute toward these goals, but at a much slower rate than could be achieved through direct investment in improving nutrition, which tends to be highly cost-effective.[1] Current nutritional interventions alone, however, are unlikely to generate these targeted improvements due to factors such as lagging health system development,[5] motivating policy-makers to seek a better understand of the underlying causes of malnutrition and methods for increasing the impact of existing efforts.

A number of factors that contribute to the persistently high child malnutrition rates in many low-income settings are well-established, including poor maternal nutrition, inadequate breastfeeding, and inappropriate complementary feeding.[2] A substantial portion of the drivers of malnutrition, however, remains poorly understood.[6] I present here the results of a pilot intervention in a rural, agricultural region of Oromia, Ethiopia, that was designed to generate insights into the contribution of (1) caregivers' knowledge barriers and (2) resource constraints toward child malnutrition, ultimately allowing for more targeted, cost-effective interventions in the future.

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[i] Stunting is defined by the World Health Organization as having a height-for-age z-score below -2.

The first potential driver of malnutrition considered in this paper, knowledge barriers, was motivated by data collected during interviews with children's caregivers during a prior child-nutrition-focused randomized trial in Ethiopia, upon which this study was built. These data suggested that insufficient knowledge about *how* to improve child nutrition was unlikely to be a limiting constraint with respect to malnutrition. On the other hand, these caregivers were commonly unaware that their children's physical size was below average; these misperceptions persisted over multiple survey rounds over the course of a year. This factual knowledge about how to provide proper nutritional intake, combined with misperceptions about children's actual nutritional status, suggests that one potential means of improving child malnutrition is to provide personalized information correcting these misperceptions, a hypothesis I test in this study.

The second potential driver of malnutrition considered in this paper, resource constraints, would be expected in many similar contexts and was verified as a likely relevant factor during the prior trial. Many children's diets consisted primarily of products that were directly produced by the household and improvements to their diets would require purchases from the local markets, an undertaking that may be – or may be perceived to be – out of reach for most households in the study area without additional financial resources.

With these motivations and input from government and local non-profit officials, I developed a set of interventions that tested potential policy measures that leaders could feasibly implement to reduce rates of malnutrition, while also providing a deeper understanding of the relationship between knowledge and resource constraints, and how these might inhibit action. The interventions were implemented through a randomized controlled trial, with two cross-randomized interventions. In the first intervention, households received personalized information about the height of a young child[i] in the household compared to the range of heights for "healthy" children of the same age and gender in East Africa. Notably from a policy and feasibility perspective, this information was based on data that are already regularly collected by community health workers in rural Ethiopia, and could easily be presented by these workers to caregivers during the community health workers' existing, regular visits to all households with children under five.[ii] In the second intervention, households received a small cash transfer labeled for child food consumption over the following six weeks.

I find that caregivers were able to internalize and recall the personalized information fairly well, and this knowledge translated into some small but meaningful improvements in feeding, spending, and growth. For example, index children in the personalized information group consumed 67 percent more eggs per week as a result of the intervention and gained 0.13 standard deviations in their weight-for-age z-scores. The labeled cash transfer was generally more effective in improving key outcomes such as the quality of the child's food consumption and household spending on key food items. This intervention led to a 166 percent increase in egg consumption and a 0.11 standard deviation increase in weight-for-age z-scores. There were no consistent complementarities between the two interventions when they are combined.

This study contributes to three main threads in the research literature: (1) the role of information – particularly personalized information – in prompting behavior change, (2) the influence of cash transfers on health behaviors and outcomes, and (3) the impact of labeling on resource allocation. These results provide a significant contribution to the literature, specifically

[i] During the prior trial, we identified an "index child" from each household who was 6-35 months old in July 2015, about one year prior to this study. These same index children were the focus of this trial, with ages ranging from 17 to 47 months during the baseline and interventions in this study.
[ii] Currently health workers collect the relevant information but typically share the measured numbers without enough context for the caregiver to form judgments about the quality of her child's growth or health status.

in contexts where general maternal education about child nutrition has effectively diffused, but poor child feeding behaviors – and therefore child malnutrition – have persisted.

Past research on promotional health campaigns (i.e., those focused on increasing general awareness and knowledge of proper diets, hygiene, etc.) has not shown reliably positive effects, particularly in food insecure contexts.[7] These findings are consistent with the current circumstances in rural Ethiopia, where caregivers are typically well-informed about proper child feeding practices, (presumably through effective promotional campaigns) but poor feeding practices and child health outcomes are common.

In contrast to provision of general knowledge, provision of *personalized* information about the child's current height draws on an important branch of the behavioral economics literature: the greater likelihood personalized or specific information has in influencing behavior compared to providing general information or exhortations to behave a certain way. For example, Jalan and Somanathan (2008) found that households in India were strongly responsive to personalized information about the quality of their own water source when deciding whether to purify their water.[8] In a related vein, several recent studies have shown that providing parents personalized information about their child's performance in school, both in the US[9, 10] and abroad[11, 12], can lead to substantial improvements in academic outcomes and behavior. Given these past findings, personalized information in this context was hypothesized to help address caregivers' misperceptions about their children's nutritional status and to stimulate households to allocate more resources to their young children's food consumption.

The second intervention, the labeled cash transfer, builds on two streams in the past research literature: cash transfers and labeling. The cash transfer literature is extensive; conditional cash transfers (CCTs) have gained popularity in developing countries based on the results of several successful programs, particularly in Latin America.[13-15] Nearly every Latin American country now has a CCT program, and, as of 2010, over a dozen sub-Saharan African countries had implemented one.[16]

CCT programs tend to focus on outcomes such as school attendance and health checkups like well-baby visits.[17] While CCT programs have been successful in these contexts (e.g., increasing school enrollment, health visits for preventive checkups[17]), they have more limited viability in a nutrition context for at least two reasons. First, the conditions that would be needed for the transfer are not typically – nor easily – measured (unlike, for example, school attendance). The conditions in existing CCT programs most closely related to nutrition are those focused on ensuring actions such as regular growth monitoring checkups.[i] To my knowledge, there are no cash transfer programs with a conditionality that is more directly related to child food consumption. Second, in this context we are seeking for households to improve their child's food consumption, which often requires an upfront cash expenditure in order to purchase additional, more nutritious, foods. CCT's are typically conditioned around an action that does not require (much of) an upfront cash outlay such as school attendance because it would otherwise be a generally unreasonable proposition for the targeted households.

As a result, we instead offered a cash transfer that was labeled for improving the quality of the child's food consumption, but was not formally conditioned on this use. Unconditional cash transfers without a label have been shown to have a positive influence on a number of outcomes, including spending on food (e.g., the Kenya Cash Transfer for Orphans and

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[i] Note, however, that even when CCT programs have been shown to increase growth monitoring checkups, there are only a limited number of cases where this behavior change has translated into improved nutritional health outcomes such a linear growth. (Fiszbein A, Schady NR. Conditional cash transfers: reducing present and future poverty: World Bank Publications; 2009.)

Vulnerable Children program), and compare favorably to CCT's in some contexts, particularly for especially vulnerable households.[15]

The impact of labeling has previously been studied in the financial and behavioral economics literatures, generally finding favorable impacts of labeling in contexts such as financial savings.[18] The labeled cash transfer (LCT) approach studied here built on the work of Benhassine, et al. (2013), which studied the impact of an LCT on school participation in Morocco and directly compared the LCT with the more traditional CCT approach. They found that LCT's were as effective as CCT's in increasing school participation, and showed that the most likely pathway for this result – besides providing moderate relief for resource constraints – was to increase the likelihood that parents believed education to be a worthwhile investment.[19] The LCT approach here also builds on the work of Haushofer and Shapiro (2013), particularly their finding that splitting the transfer into smaller, periodic installments shifts spending from larger lump sum items to more frequent expenses, resulting in improved food security for households receiving the periodic installments. As a result, in this study we split the 6-week cash transfer into six labeled envelopes with equal amounts of money in each envelope. Based on these past research findings, the LCT in this context was hypothesized to help relieve some of households' resource constraints and incentivize them to allocate additional financial resources toward their young children's food consumption.

This paper is closely related to Levere, et al. (2016), which analyzes an intervention that is similarly motivated to the work here: easing the malnutrition burden, especially among young children.[6] Their study, conducted in Nepal, has some similarities to this one: one set of treatment households is given information about nutrition and parenting,[i] while a second is additionally

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[i] Each family received booklets on the benefits of breastfeeding, use of vitamins, and nutritious food.

given an unconditional cash transfer. While there are a number of differences in implementation[i], one of the key conceptual differences is that Levere, et al.'s study focused on educating households about *what* to do, whereas in the context analyzed here, caregivers had already demonstrated ample knowledge in that domain. This study specifically tests what means there are for incentivizing behavior even when the relevant population already has strong general knowledge. Moreover, it demonstrates that it is possible to convey relatively nuanced information in a manner that is digestible and memorable for a low-literacy population, moving beyond general knowledge.

The next section provides background on the experimental setting and describes the personalized information and labeled cash transfer interventions. Section 3 provides information about the experimental design and data. Section 4 describes the main empirical specification, outcomes and mechanisms examined, and a brief analysis of attrition. In Section 5 I present the main results, as well as some evidence corroborating these findings. Section 6 examines mechanisms that provide greater nuance in interpreting the main results. In Section 7 I conclude with a discussion of the results.

Background and pilot randomized trial

Study context

At $1,900 per person, Ethiopia's purchasing power parity GDP ranks 208th in the world, and is relatively low compared to other sub-Saharan African countries.[20, 21] Almost three quarters of the population is engaged in agriculture, where growth is fairly strong.[20] Like most of its neighbors, many of Ethiopia's health indicators are improving, but remain substantially

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[i] For example, the information intervention was generally educational and was provided multiple times, via community members with whom households were already familiar.

worse than those of developed countries. For example, Ethiopia's under five mortality rate in 2016 of 59 deaths per 1,000 live births is ten times higher than in OECD nations, but reflects a significant decline from its 2000 rate of 166.[21] Similarly, its under-five stunting rate has fallen by more than a third over the same period, estimated at 38 percent in 2016.[22]

Malnutrition has serious consequences for Ethiopia's economy: the long-term effects of child undernutrition are estimated to reduce the country's overall GDP by about a sixth.[23] Reflecting the desire to improve childhood nutrition, in the Second Growth and Transformation Plan the Ethiopian government set the target of reducing its stunting rate to 26 percent by 2020, a 35 percent reduction compared to the baseline rate, 40 percent, in 2015.[24] In the Seqota Declaration, the government pledged to eliminate child malnutrition entirely by 2030.[25]

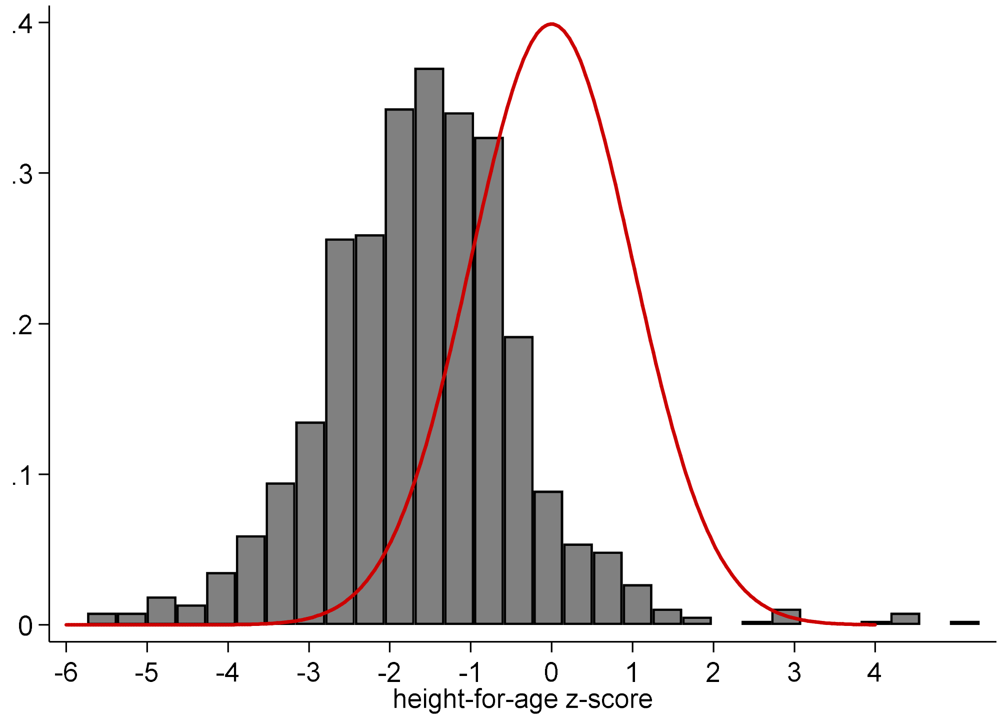
Partially targeting these goals, the Ethiopian government has improved supply-side health care provision. Its Health Extension Program (HEP) was initiated in 2003 as part of the 20-year Health Sector Development Program in order to help control communicable diseases, equitably increase access to modern healthcare, and improve awareness and community participation in healthcare provision.[26] The HEP aims to provide promotive, preventive, and some curative health interventions through its 30,000 government-employed health extension workers (HEWs). These HEWs are local women with at least a grade 10 education who are given one year of training. In rural areas, two HEWs are assigned to a health post, typically designed to cover 25,000 people. They are expected to spend about three quarters of their time on outreach, focusing on households with pregnant women and children under five.[27] In practice, households are visited at least once a month.[26] By 2010, almost all rural villages formed of farmers (rather than nomads) were covered by the HEP, expanding both health services and access to vaccines.[28, 29]

This trial was conducted with a subset of the study population involved in a prior, larger randomized trial.[30] Data collected during the previous trial demonstrate that the Health Extension Program has been extremely effective in some respects, including in educating caregivers for young children about proper child nutrition. In a survey conducted in July-August 2015 in the study population, when caregivers of children 6-35 months old were asked what they could do to help a child grow taller and to gain weight, 65 percent said to feed the child more and 86 percent said to feed the child a wider variety of foods (both responses were unprompted).

Past evaluations of feeding practices (e.g., foods eaten, meal frequency) demonstrate that these mothers' responses are correct. Nutritional intake is strongly associated with childhood growth in low income settings, including after accounting for socioeconomic status, even when there are a number of competing factors that likely hinder childhood physical development (e.g., infectious diseases). Ruel and Menon (2002) examined child feeding practices using data from the Demographic and Healthy Surveys in five countries, and found that feeding practices are strongly associated with anthropometric outcomes such as height-for-age z-scores, particularly for children older than one year.[31] Children whose feeding practice scores ranked in the top tercile had, on average, a 0.5 z-score advantage, compared to those in the bottom tercile.[31] Arimond and Ruel (2004) confirmed this relationship in several more countries, finding an especially strong link in Ethiopia.[32]

Despite knowing how to improve child growth, evidence suggests that households in rural Ethiopia are likely not currently able or sufficiently motivated to provide adequate nutritional intake for their children. Figure 8 shows the distribution of height-for-age z-scores of the index children from the study households, as measured in July 2016 (i.e., just prior to the interventions) when they were an average of 30 months old (ranging from 17 to 47 months). In

Figure 8: Overall height-for-age z-score distribution



Notes: The distribution of height-for-age z-scores (HAZ) for all children (n=505), as measured approximately 2 weeks prior to the baseline survey and interventions, is shown in the gray histogram. A standard normal density, the expected distribution in a normal distribution of children, is shown in red.

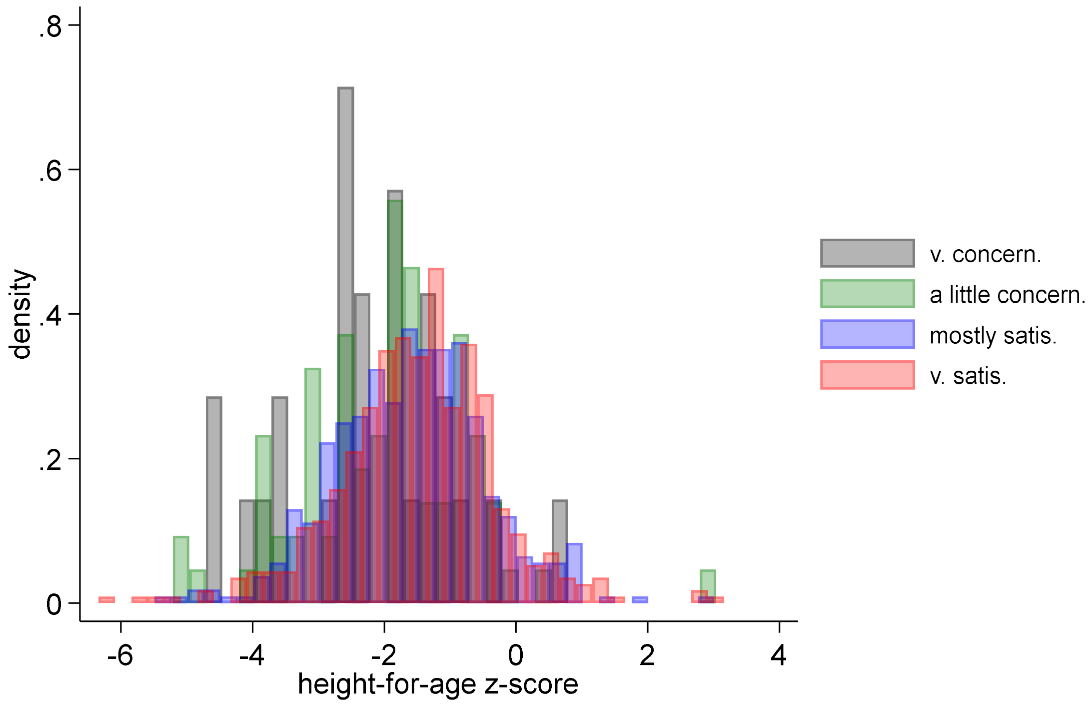
the average population, this distribution is expected to be centered around 0, as shown by the red density line, but the mean for children in the study area is much lower, at -1.5. Just over a third of children fall below the cutoff for moderate malnutrition (HAZ<-2), roughly in line with Ethiopia's overall rate.

While there are nutritional deficiencies among children in rural Ethiopia, despite knowledge among caregivers about how to address these deficiencies, previously collected data also suggest that caregivers are not fully aware that a problem exists – a pattern that persisted over multiple survey rounds. In a January 2016 survey, caregivers were asked about their perceptions of their young child's growth, and could give answers ranging from "very concerned" to "very satisfied". As shown in Figure 9, while concern levels seem to be correlated with HAZ on average, there are large groups of women whose concern levels do not match with their child's actual height status. For example, more than a fifth of children whose mothers were "very satisfied" with their growth fell below standardized cutoffs for stunting.[i]

This lack of correlation between the child's true height status (i.e., how her height compares to an average population) and the caregiver's concern may be anticipated for at least two reasons: (1) caregivers are most commonly comparing their children to other children in the community, who likely also suffer from similar growth deficiencies, and (2) children suffering from chronic malnutrition may appear not to have any obvious physical growth deficiencies since their weight may appear to be appropriate given their height – the issue is most present in

[i] We also asked caregivers to rank on a scale from 1 to 10 where they believed their child's height was compared to other children the same age and gender in their village. As shown in Figure 15, caregivers' beliefs about their child's actual height status were at times far removed even from their local reality. When comparing to other children in the community, 24 percent of those who ranked their child below average actually had a child who was above the community average in height, and 43 percent of those who ranked their child above average actually had a child who was below the community average in height (standardized for age and gender).

Figure 9: Height-for-age z-scores by caregiver concern, pre-intervention



Notes: The distributions of height-for-age z-scores for all children (n=505), as measured in January 2016, are shown, separated by the caregiver's concurrent concern level for the child's growth (caregivers chose between four options: very concerned, a little concerned, mostly satisfied, and very satisfied).

their height, whose appropriateness is typically difficult to gauge, especially given the first challenge.

Pilot randomized controlled trial

Study population

The study took place in rural regions of Oromia, Ethiopia, where most households are engaged in agriculture and have a low socioeconomic status (more detailed demographics are discussed below and shown in Table 6). Households for this study were randomly selected from among those who were included in any of the three study groups from a larger study and for whom relevant data had been collected.[i] Briefly, inclusion in the larger study required the household to have a child who was 6-35 months old for the previous study's baseline survey in July-August 2015 (referred to as the "index child"[ii], 17-47 months at the beginning of this study) and for the household to have land for crop cultivation. 521 households were initially selected for this study, with 16 attriters due to relocation or caregiver illness. The geographic area for the households for this study is shown in Figure 10.

General child nutrition information

All households in the study were given general child nutrition educational messaging, immediately after the baseline survey and prior to any treatments. This messaging focused on appropriate child feeding habits complemented by breastfeeding and ways to maintain proper hygiene during food preparation and consumption.[iii] The messaging emphasized beneficial

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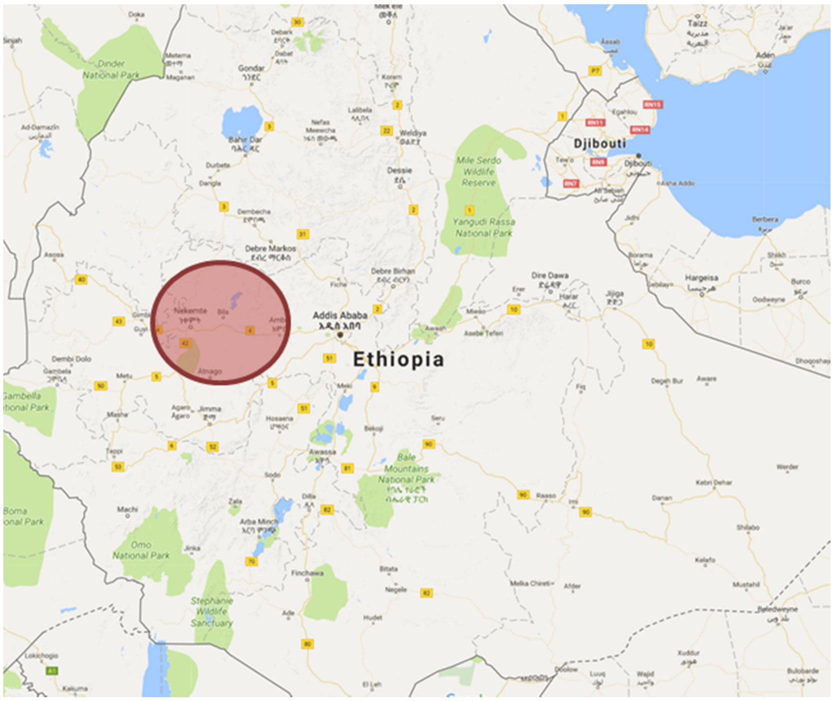
[i] Households could only be included if we had successfully collected the following information during the previous, larger study: index child's height, age, gender, whether the caregiver attended school, and the number of people in the household. Randomization into study groups for this study was stratified by the previous study group.
[ii] If there was more than one child in the relevant age range, the youngest child was selected as the index child.
[iii] The messages were adapted for the local context from standard child nutrition guidelines developed by UNICEF, found at: http://www.unicef.org/nutrition/files/counseling_cards_Oct._2012small.pdf.

Figure 10: Map of the study region



actions that were feasible in the context, especially egg consumption.[i] The specific script and accompanying visual guide are shown in the supplementary materials.

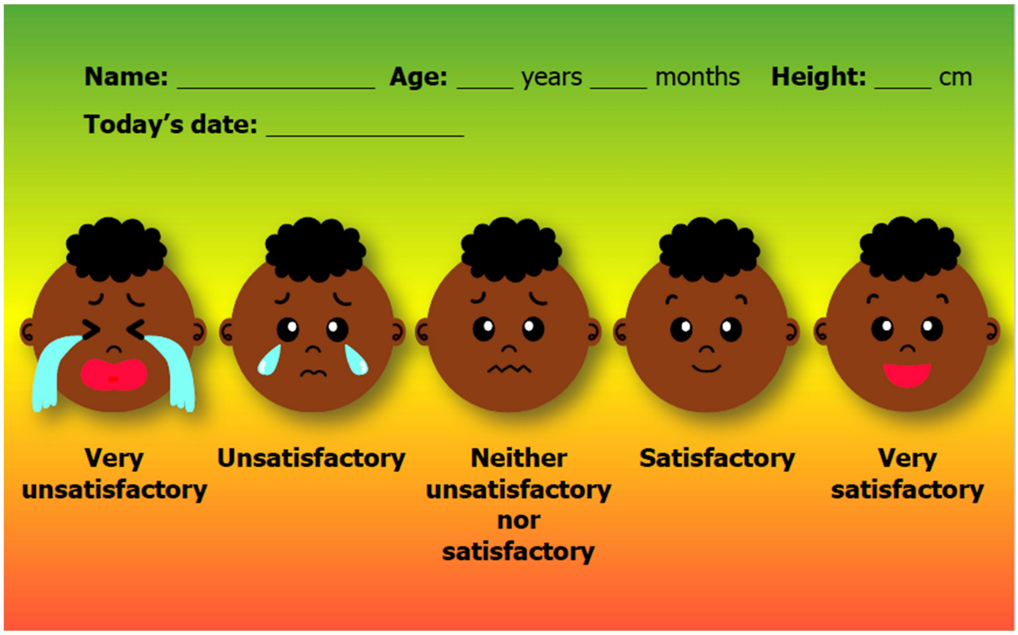
Treatment 1: Personalized information treatment

In June-July 2016, just prior to this study, we collected anthropometric measures on the index children, including the children's height. Based on these data, for households assigned to the information treatment, enumerators provided personalized information to the index child's primary caregiver about the child's current height. The enumerators carried a small poster that visually showed where the child's height fell compared to "healthy" children of the same age and gender in East Africa. An English version of this card is shown in Figure 11. In practice, a child was indicated to be in the lowest category (of 5) if her HAZ was <-2, the second if -2<HAZ<-1, the third (middle) if -1<HAZ<0, the fourth if 0<HAZ<1, and the highest if HAZ>1. A third of children fell into each of the first two categories, less than a quarter were in the third, and the remaining 9 percent were in the top two categories.

Before circling the index child's position on the poster, the enumerators ensured that the caregivers understood the visual guide by pointing to 3-4 positions on the figure (including at least once at the second or fourth position, to be sure of an adequate understanding of the more nuanced positions) and asking the caregiver to explain what such a position indicated. The enumerators emphasized to the caregivers that short stature is due to poor *chronic* malnutrition and is not just attributable to factors such as a family tendency for short stature or a recent illness. During this visit, the enumerators additionally pointed out that chronic malnutrition is

[i] Note that the previous study focused on an improved maize variety, Quality Protein Maize, so a subset of the households had recently received educational messaging around protein and its importance for child growth (randomization for this study stratified by previous treatment group).

Figure 11: Display poster for personalized information



Notes: English-language replication of the small poster that caregivers in the personalized information intervention received. Prior to circling the index child's height position, the enumerators explained the five positions, and ensured that the caregivers understood the scale by asking each caregiver to explain the meaning of 3-4 positions (including at least one of the second and fourth positions). After ensuring that the caregivers understood the scale, the enumerators filled out the blanks at the top of the poster, and circled the index child's height position. A child was indicated to be in the lowest category if her height-for-age z-score (HAZ) was <-2, the second if -2<HAZ<-1, the third (middle) if -1<HAZ<0, the fourth if 0<HAZ<1, and the highest if HAZ>1. A third of children fell into each of the first two categories, less than a quarter were in the third, and the remaining 9% were in the top two categories.

not immediately life-threatening.[i] All of the information used for the personalized information is already regularly collected by community health workers in Ethiopia, but the information was visually presented in a way that provided context for the caregiver to evaluate her child's nutritional status (i.e., physical size).

The personalized information did not focus on weight because: (1) it is generally easier for parents to identify that their child does not weigh enough (i.e., wasting) compared to knowing that their child is too short (i.e., stunting) since a child who is wasted will have relatively obvious markers such as unusually thin limbs, so providing this information is less likely to correct past misperceptions, and (2) the focus of this study is on addressing chronic malnutrition, which is better represented by height, rather than acute malnutrition or recent illness, which are more related to weight.[33]

Treatment 2: Labeled cash transfer treatment

Caregivers in households assigned to the second treatment received a cash transfer labeled for child food consumption. The caregivers were told the money is designed to cover *additional* spending for food for the index child (and any other younger children in the household) over the next six weeks, and not to free up money for other household purchases that would have occurred regardless. The cash transfer had multiple "labeling" dimensions designed to overcome behavioral biases. First, in order to encourage the caregivers not to spend the money all at once, the transfer was evenly split and handed to the caregivers in six sealed envelopes that were labeled with a number 1 to 6 and the dates for the week the money in the envelope should be spent. Second, in order to encourage the caregivers to use the money only

[i] Any child who was found to have acute malnutrition would have been referred during the anthropometric measurements prior to the study, and would not be included in the sample.

for additional spending for the index child, the index child's name was written on each of the six envelopes. Enumerators clearly stated that this was a one-time money transfer, and ensured privacy when distributing the money to the caregiver, including from other family members.

The total value of the transfer, 150 birr (about $7.50 at the time of the intervention), was designed to provide sufficient money to purchase eggs 5-7 times per week, as these were found during piloting and focus groups to be the primary food that caregivers felt they would like to feed their young children more but cannot afford.[i] Previously studied cash transfer schemes have had a wide range of transfer values, ranging from a few percent up to 20 or more percent of mean household income.[17] The per-week cash transfer amount studied here (25 birr, $1.25) is mid-range, amounting to just over 15 percent of average weekly spending.

Experimental design and data

I evaluate the impact of the randomized trial using two waves of data collection from study households and local markets; the first round occurred just prior to the interventions and the second occurred 6 weeks later.[ii] Baseline surveys were conducted in July 2016 with 515 households across 8 kebeles[iii]. In the randomly selected treatment households, the interventions were delivered to the index child's primary caregiver immediately after the baseline survey.[iv] The endline surveys were conducted in August-September 2016, with 505 households. The entire study occurred over two of the most food insecure months of the year for the average household in the study area.

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[i] While mothers frequently referenced milk as something they would like to feed their children, it is uncommon in the study area to purchase milk from the market, so eggs were given the most emphasis.

[ii] In practice, follow up surveys occurred 4.3-7.3 weeks after the baseline surveys, with more than three quarters occurring between 5 and 6 weeks after baseline.

[iii] A "kebele" is a group of villages and the smallest administrative unit in Ethiopia, generally covering about 500 households or 3,500-4,000 people.

[iv] In cases where the household was selected for both treatments, the personalized information treatment always preceded the cash transfer treatment.

The interventions and survey questions were extensively tested near the study area prior to the data collection and interventions through focus groups and individual piloting. Many of the survey questions were drawn from standard questionnaires (e.g., the Demographic and Health Surveys), with minor modifications to reflect regional differences. The baseline and endline caregiver surveys were nearly identical, apart from two additional modules that were included at the endline for households in each of the treatment groups. The surveys included questions about recent food consumption (7 day and 24 hour recall for the index child, 7 day recall for other key family members), spending, caregiver perceptions and beliefs about child growth, parental involvement, satisfaction, empowerment, food security, and child illness. Additionally, we collected prices for key food items (e.g., maize, eggs, cooking oil) from the largest market in each study community. The primary outcomes of interest relate to the index child's food consumption and the household's expenditures.

Households were randomly assigned, with equal probability, to one of four study groups: (1) control, (2) personalized information only, (3) labeled cash transfer only, or (4) personalized information and labeled cash transfer. The randomization was stratified by treatment group from the larger study on which this pilot was built and whether the index child's caregiver had ever attended school (one third of the sample). The randomization was carried out using the *randomize* Stata command, set to achieve balance on the index children's height-for-age z-scores, as measured a couple weeks prior to the baseline and intervention, and the household size, as measured 4-5 months prior to the start of the study. Ultimately there were 124 households in the control group, 126 in the pure personalized information group, 123 in the pure labeled cash transfer group, and 132 in the joint personalized information plus labeled cash transfer group.

Baseline mean values for index child, caregiver, and household characteristics in each the study groups are shown in Table 6. The values in the last column show the p-value for an F-test of equality across the four groups; starred values indicate that the study group is individually statistically significantly different from the control group, at the indicated levels. The study groups are statistically indistinguishable at baseline on almost all measures. The one household characteristic that shows imbalance overall is whether the household's primary water source is unprotected, which is significantly more likely to be true for households in the control group. Among measures of the index child's food consumption, the number of days in the past week that the child consumed eggs is not balanced, with one of the cash transfer groups showing significantly higher baseline magnitudes. The full distribution of baseline 7 day egg consumption is shown in Figure 17 (supplementary materials), which shows that the imbalance is driven primarily by a few outlier cases; dropping the four cases where the caregiver reported the index child consuming eggs every day of the last week results in a p-value from the test of equality across groups of 0.15. Given that my analyses are conducted accounting for baseline values and that these high values are present in a treatment group, there is not a strong concern of bias even with this baseline imbalance.

Overall, Table 6 shows the relatively poor nutritional status of children and low socio-economic status of households in the study sample. For example, a third of children in the sample are stunted (HAZ<-2), two thirds of caregivers never attended school, and about a quarter of the households has no toilet. Index children's diets most frequently included cereal-based foods and those made with oil, butter, etc. These values are in line with rural Ethiopia as a whole, as measured through the 2016 Demographic and Health Survey.

Table 6
Pre-intervention Index Child, Caregiver, and Household Characteristics

Variables	Control (1)	Pers. Info. (2)	Cash Transfer (3)	Pers. Info. & Cash Transfer (4)	p-value (all) (5)
A. Index child characteristics					
Male	0.53	0.44	0.54	0.58	0.11
Age (months)	30.53	31.55	31.74	29.62	0.16
Height-for-age z-score	-1.71	-1.68	-1.56	-1.58	0.64
Weight-for-age z-score	-1.09	-1.15	-1.03	-1.00	0.66
Weight-for-height z-score	-0.24	-0.31	-0.25	-0.29	0.92
Body mass index-for-age z-score	0.00	-0.08	-0.03	-0.07	0.90
B. Caregiver characteristics					
Age (years)	28.07	28.63	28.45	28.33	0.91
Height (cm)	158.23	158.46	157.33	157.64	0.38
Muslim	0.10	0.08	0.06	0.11	0.33
Ever attended school	0.33	0.34	0.34	0.34	1.00
Total number of pregnancies	4.28	4.21	4.23	4.18	0.98
C. Household characteristics					
High quality roof	0.52	0.57	0.53	0.56	0.86
No toilet	0.28	0.26	0.25	0.21	0.51
Unprotected surface water	0.52	0.38**	0.39*	0.31**	0.01
Electricity in household	0.06	0.07	0.04	0.08	0.60
Ox plough	0.90	0.90	0.90	0.90	1.00
Household size	5.96	6.09	5.98	6.06	0.95
Number of HH members 6-59 months old	1.61	1.48*	1.53	1.49*	0.18
D. Index child food consumption (days last week)					
Cereal-based foods	6.90	6.83	6.90	6.70	0.32
Bread/biscuits or pasta	1.15	0.99	0.98	1.12	0.69
Meat or fish	0.26	0.33	0.32	0.21	0.55
Fruits	1.08	0.89	0.91	0.94	0.84
Vegetables	5.17	4.94	4.90	5.03	0.82
Eggs	0.35	0.29	0.67**	0.43	0.03
Milk or dairy products	2.31	2.34	2.78	2.45	0.50
Legumes (beans, peas, lentils)	3.62	3.95	3.83	3.90	0.70
Foods made with oil, butter, etc.	6.33	5.94*	5.97*	6.23	0.21
E. Index child food consumption quality					
Minimum dietary diversity	0.39	0.41	0.47	0.33	0.15

Table 6 (continued)

Minimum meal frequency	0.42	0.41	0.49	0.45	0.61
Minimum acceptable diet	0.19	0.17	0.29**	0.23	0.12
N	124	126	123	132	

Notes: Means for each study group are reported in columns (1)-(4). The p-value from an F-test that all coefficients jointly equal zero is reported in column (5). * indicates the study group is statistically significantly different from the control group at the 10% level. ** indicates the study group is statistically significantly different from the control group at the 5% level. Minimum dietary diversity is an indicator for whether the index child received foods from at least 5 of the following 7 food groups in the last 7 days: (1) cereals/bread/pasta, (2) legumes, (3) dairy products, (4) flesh foods, (5) eggs, (6) fruits, and (7) vegetables. Minimum meal frequency in an indicator for whether the child received at least 3 meals if still breastfeeding, or at least 4 meals if not still breastfeeding, in the last 24 hours. Minimum acceptable diet is an indicator for whether the child's recent food consumption met the requirements for both minimum dietary diversity and minimum meal frequency.

Empirical Strategy

Empirical specification

Given random assignment to each intervention and measurement of almost all outcomes at both baseline and endline (six weeks apart), we identify short-term causal treatment effects through the following specification:

$$y_{it} = \beta_0 + \beta_1 PersInfo_i \times POST_t + \beta_2 LCT_i \times POST_t + \beta_3 PI_i \times LCT_i \times POST_t + POST_t + \gamma_1 IndexChildChars_i \times POST_t + \gamma_2 HHChars_i \times POST_t + \gamma_3 PrevTx_i \times POST_t + \alpha_i + \epsilon_{it}$$

Where y_{it} is the outcome for individual/household i at time t

$PersInfo_i$ is an indicator equal to 1 if individual/household i is selected for the personalized information treatment

LCT_i is an indicator equal to 1 if individual/household i is selected for the labeled cash transfer treatment

$POST_t$ is an indicator equal to 1 at endline

$IndexChildChars_i$ is a vector of index child characteristics (age, gender)

$HHChars_i$ is a vector of the household characteristics in panel C of Table 6

$PrevTx_i$ is a vector of indicators for treatment groups in the previous study

α_i are household (i.e., child) fixed effects

The key coefficients of interest are β_1, β_2, and β_3, which give estimates of the average treatment effects of the interventions, controlling for baseline values. When analyzing mechanisms (e.g., whether the caregiver had attended school), I additionally include the mechanism interacted with all factors involving the indicator for post and interacted with all study group indicators (all mechanisms are based on characteristics measured at baseline).

Because comparisons across the three treatment groups, in addition to directly with the control group, are informative when analyzing the interventions, I report p-values for several tests in the last four rows of the results tables that correspond to various combinations of tests of equality of groups: (1) personalized information alone = labeled cash transfer alone ($\beta_1 = \beta_2$), (2) personalized information alone = personalized information and labeled cash transfer ($\beta_1 = \beta_3$), (3) labeled cash transfer alone = personalized information and labeled cash transfer ($\beta_2 = \beta_3$), and (4) an F-test that all coefficients jointly equal zero ($\beta_1 = \beta_2 = \beta_3$).

Outcomes and mechanisms examined

The interventions were ultimately aimed at improving the nutritional status (i.e., growth) of the index children. In addition to children's growth, we focus the analyses on three key intermediate outcomes: (1) caregivers' perceptions of the child's growth, (2) index children's food consumption, and (3) household spending.[i]

Caregiver beliefs, recall, and concern

I begin with a brief analysis of caregivers' ability to recall the information we told them (in the personalized information group) and then of changes in their perceptions about their children's nutritional status and growth. Within the personalized information group, we report how well caregivers were able to recall the information we provided to them 6 weeks prior. Across all groups, we then briefly examine how the interventions influenced caregivers' perceptions of their own child's position on the 5 point Likert scale comparing to other healthy

[i] The main outcomes were pre-specified on clinicaltrials.gov: NCT02903641.

children the same age and gender from East Africa, how that compares with the child's actual position, and the impact on caregivers' concern for their children's growth. These measures are useful for establishing whether the information provided to the caregivers was memorable, but we interpret responses as reflecting both changes in the caregivers' actual perceptions and their knowledge of the "correct" responses after being given the new information about their child's actual height position.

Index child's food consumption

In Ethiopia complementary foods (i.e., those fed to children transitioning from breastfeeding to family foods) tend to be made from cereals or root crops into a thin, starchy gruel or an unleavened bread.[34] It is therefore unsurprising that two thirds of the foods that Ethiopian children 6-23 months consume are grain-based.[35] These grain-based foods are nutritionally problematic both due to the low protein content and the difficulty for the caregiver in assessing how much the child has actually consumed.[36] As a result, the general nutrition education that was provided to all caregivers in the study emphasized the importance of protein-rich foods in young children's diets. These foods are therefore also the focus in the analyses below, measured through 7 day food recalls where the caregiver is asked how many days in the past week the index child consumed a range of food groups, including eggs, meat or fish, and legumes.

The quality of a child's food consumption extends beyond what specifically the child eats, including factors such as the frequency and diversity of consumption. I adapt three measures the WHO has developed to measure these dimensions of a child's food consumption quality[37]: (1) minimum dietary diversity, (2) minimum meal frequency, and (3) minimum acceptable diet. The first, minimum dietary diversity, is a binary indicator for whether the index child consumed at least 5 of 7 food groups in the past week: cereals/bread/pasta, legumes, dairy products, flesh foods, eggs, fruits, and vegetables. The second, minimum meal frequency, is a binary indicator for whether the child received at least 3 meals if still breastfeeding, or at least 4 meals, if not still breastfeeding, in the last 24 hours. The final, minimum acceptable diet, is a binary indicator for whether the child met the requirements of both minimum dietary diversity and minimum meal frequency.

Household spending

For most households in the study area, improving the index child's food consumption would require purchasing more or different foods in the market. For example, less than a third of the households had a hen that produced eggs, and even those who did have a hen would likely need to purchase some eggs from the market to make a substantial increase in their child's egg consumption. As a result, increases in spending on key food items in households receiving the personalized information treatment should have occurred (at least on average), if the information was sufficiently compelling (i.e., different from baseline beliefs and believable), the caregiver knew how to improve the quality of the child's consumption, and the household had any budgetary slack or opportunity for reallocating its spending. Considering that the cash transfer was labeled as being specifically for increasing the quality of the index child's food consumption, spending on key food items should plausibly increase among households receiving this intervention as well.[i]

In order to measure changes in spending, we asked caregivers about their household's spending on a range of food items, as well as most common expenses (e.g., transportation, school

[i] Other relevant factors, such as budgetary slack, are further considered in Section 6.

fees, health expenses), over the past month. Among these regular expenses, food expenses made up nearly three quarters of spending for the average household.

As with any cash transfer, it is of interest – and potentially concern – whether the cash leaks into savings or spending on unintended items. Leaks into spending on something like health expenses or savings may have ambiguous welfare effects – or at least efficiency concerns since there may be more effective ways to improve these outcomes, whereas increased spending on vice goods like alcohol or tobacco may have a more clear interpretation. We therefore also conduct a brief analysis of impacts on non-food spending.

Index child anthropometrics

The ultimate goal of this and other child nutrition-focused interventions is to improve children's nutritional status – in other words, the child's physical growth. Children's nutritional status is most commonly measured through age- and gender-standardized z-scores related to the children's height and weight. In this study, we analyze three of these common measures: (1) height-for-age z-score, (2) weight-for-height z-score, and (3) height-for-age z-score, all based on the 2006 WHO child growth standards. While we may plausibly see short-term improvements in weight, it typically takes 6-12 months for measurable differences in group-level standardized measures related to height to become apparent.

Secondary analyses

In order to better understand for what subgroups the interventions were most effective, we analyze the effects on two key outcomes, the index child's egg consumption and an indicator for minimum dietary diversity, stratified by three characteristics: (1) baseline height-for-age z-score, (2) baseline weight-for-age z-score, and (3) index child's sex. We may expect that the effects are more or less pronounced for children who are more vulnerable, and these stratifications provide suggestive evidence around this.

Additionally, because results around feeding and spending are self-reported (while enumerators were blinded to the treatment when asking these questions, respondents necessarily were not at endline), we conduct a brief analysis to examine the internal consistency of respondents' answers to questions that were asked at different times during the interviews. Specifically, we examine whether reported changes in consumption of and spending on eggs are plausible within a household.

Mechanisms

We explore four potential mechanisms that may help explain when the interventions were most effective: (1) whether the caregiver controls the household's money, (2) whether the caregiver attended any school, (3) whether the household faces a particularly strained budget, and (4) whether the information provided is worse than the caregiver's prior beliefs. Whether the caregiver controls the money is an indicator for whether the caregiver reported at baseline that she, or she with the household head, usually decides how the household's money is spent. Budgetary strain is an indicator for the caregiver reporting, at baseline, at least one of: (1) the household borrowed money in the previous six weeks, or (2) the household had any unexpected monetary expenses in the past month (e.g., illness, conflict with neighbors). Worse information is an indicator for cases where the caregiver's baseline beliefs about where the child falls on the 5 point Likert scale is higher than the child's actual position (i.e., that the caregiver overestimated the child's relative height).

In the first case, it is hypothesized that in cases where the caregiver has control over the household's money, both interventions are more likely to be effective since both are targeted at the caregiver. In the second case, it is not clear how greater caregiver education would influence the effect of the interventions. One hypothesis is that caregivers who had some education would be more responsive to the interventions given past socioeconomic gradients in responsiveness to similar interventions. Another compelling ex ante hypothesis is that caregivers with more education would have already been allocating food in relatively optimal ways, suggesting that the effect would be larger for those with a lower socioeconomic status. It is also not ex ante clear how budgetary strain should influence responsiveness to the interventions. Those who are relatively budget constrained may be more responsive to the cash transfers, but may also be less able to allocate the unexpected cash infusion in the intended manner. Finally, receiving new information that the index child is doing worse than the caregiver previously believed may inspire behavior change, or, conversely, may discourage caregivers.

Attrition

Given that this study was built upon a prior, larger study, attrition was unusually low for a field study, about 3 percent. There were initially 521 households selected for the study. We conducted baseline surveys and the interventions with 515 of these, and successfully reached 505 of these for the endline survey. Overall, attrition rates for the four study groups ranged from less than 1 percent to 4.6 percent.[i]

Results

Caregiver beliefs, recall, and concerns

I begin by describing caregivers' beliefs about their child's nutritional status, as measured just prior to the interventions. The distributions of true height-for-age z-scores, separated by the

[i] Attrition across the three study groups was: control: 6/130; personalized information only: 4/130; labeled cash transfer only: 5/128; personalized information and labeled cash transfer: 1/133.

caregivers' pre-intervention beliefs, are shown in Figure 12. Consistent with earlier rounds of data collection with similar questions, there is not a strong right-ward shift in distributions of the HAZ scores as caregivers' perceptions increase. Moreover, there are significant densities of cases where the caregivers' perceptions are extremely incorrect (e.g., a belief that the child is very tall whereas she is truly far below a healthy height).[i]

Among those who received the personalized information at baseline, 22 percent of caregivers reported being unable to recall the information they were given about their child's height position at the endline 6 weeks later. Among those who did report remembering, 74 percent did actually remember correctly and 87 percent reported a recalled height position within one position of the child's actual height position.[ii]

Index child's food consumption

In Table 7, I report the impact of the interventions on outcomes related to the index child's food consumption. Compared to a baseline mean in the control group of 0.36 days where eggs were consumed per week, index children in the personalized information group consumed eggs 0.24 more days per week as a result of the intervention, corresponding to a 67 percent increase. Children in the cash transfer groups increased their consumption by more than 0.6 days, a 166 percent increase in egg consumption. There do not appear to be any meaningful differences in egg consumption associated with adding the personalized information treatment to

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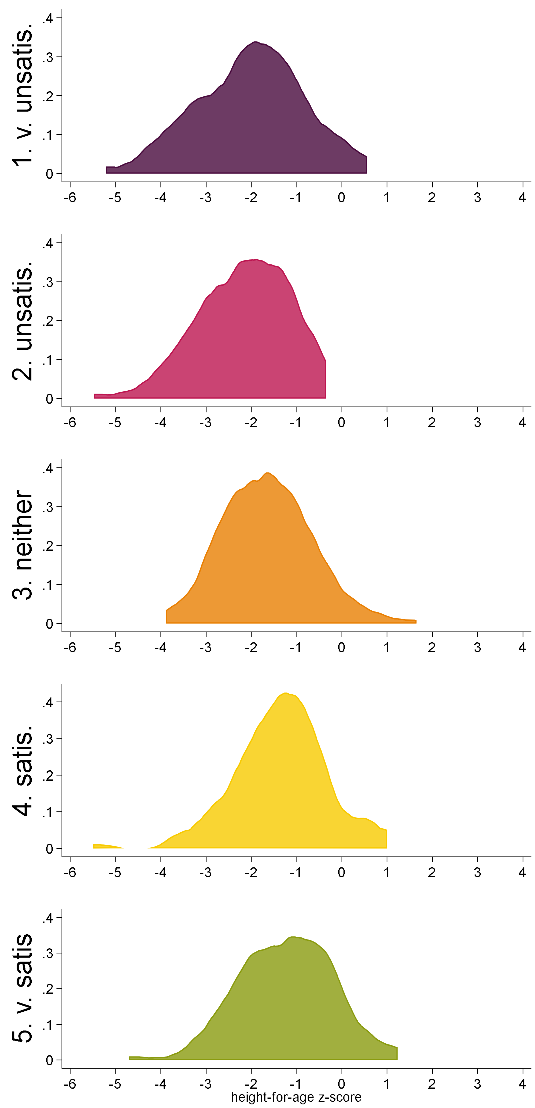
[i] The same distributions are shown split by study group in Figure 18; this pattern is consistent across treatment groups.

[ii] In Table 16 of the supplementary materials, I show additional evidence that caregivers gained and internalized new information through the personalized information intervention. Caregivers in the personalized information group reported perceived height positions for their children of 0.4 steps lower (on a 5 point scale), as shown in Column 1. The second specification further shows that the discrepancy between the caregivers' perceived position for their index child and the child's actual position decreased by about 0.4 steps for caregivers who received the personalized information. Despite these changes in perception (combined with their knowledge of the "correct" position), there do not appear to be substantial changes in concern about the child's growth, shown in the final specification.

Figure 12: Baseline beliefs and actual height-for-age z-scores



Notes: Distribution of height-for-age z-scores at baseline, broken down by caregivers' baseline beliefs about their child's height position ("very unsatisfactory" to "very satisfactory").

Table 7
Program Impact on Index Child Food Consumption

Dependent variable Specification:	eggs (days) (1)	meat/fish (days) (2)	legumes (days) (3)	min. dietary diversity (4)	min. meal frequency (5)	min. acceptable diet (6)
PI x Endline	0.239**	0.073	-0.248	0.064	0.02	0.086
	(0.116)	(0.138)	(0.35)	(0.072)	(0.065)	(0.062)
LCT x Endline	0.619***	0.273**	-0.267	0.205***	0.122*	0.123*
	(0.187)	(0.134)	(0.357)	(0.075)	(0.067)	(0.066)
PI x LCT x Endline	0.739***	0.288**	-0.283	0.322***	0.122*	0.103
	(0.171)	(0.133)	(0.335)	(0.078)	(0.068)	(0.064)
Endline	0.028	-0.053	2.080**	-0.134	-0.360**	-0.097
	(0.504)	(0.319)	(0.877)	(0.201)	(0.172)	(0.163)
Mean control group (BL)	0.355	0.258	3.621	0.387	0.419	0.185
No. children	498	498	498	498	498	498
R-squared	0.658	0.621	0.672	0.662	0.750	0.650
p-values associated with tests of equality						
(a) PI = LCT	0.047	0.172	0.957	0.055	0.107	0.600
(b) PI = PI x LCT	0.004	0.144	0.916	0.001	0.104	0.795
(c) LCT = PI x LCT	0.597	0.917	0.964	0.135	0.995	0.786
(d) F-test (all coeff's = 0)	0.006	0.265	0.994	0.003	0.169	0.871

Table 7 (continued)

Notes: Coefficients from main regression model are reported, with robust standard errors in parentheses. All specifications include controls for the household characteristics listed in Table 6 interacted with an indicator for endline, as well as the index child's age and gender and controls for the household's previous treatment group, all interacted with an indicator for endline. The outcome in column (1) is a measure of the number of days in the past week that the index child consumed eggs, (2) number of days in the past week the index child consumed meat or fish, and (3) number of days in the past week the index child consumed legumes. The outcome in column (4) is an indicator for whether the index child received foods from at least 5 of the following 7 food groups in the last 7 days: (1) cereals/bread/pasta, (2) legumes, (3) dairy products, (4) flesh foods, (5) eggs, (6) fruits, and (7) vegetables. The outcome in column (5) in an indicator for whether the child received at least 3 meals if still breastfeeding, or at least 4 meals if not still breastfeeding, in the last 24 hours. The outcome in column (6) is an indicator for whether the child's recent food consumption met the requirements for both minimum dietary diversity (column 4) and minimum meal frequency (column 5).
***p<0.01, **p<0.05, *p<0.1

the labeled cash transfer, though adding the cash transfer does increase the effect compared to provision of personalized information alone. There are also large and significant increases in days of meat or fish consumed in the cash transfer groups, but no effects for the personalized information alone group. Finally, there do not appear to be any effects on legume consumption. The full set of nine analyzed food groups are shown in Table 17 of the supplementary materials, where similar patterns of effects are shown for other key food groups.[i]

When considering the measures of dietary quality, the largest effects are again seen in the labeled cash transfer groups. In the labeled cash transfer groups, meeting the requirements for minimum dietary diversity increased by 21 to 32 percentage points, for minimum meal frequency by 12 percentage points, and for minimum acceptable diet by 10 to 12 percentage points (though only statistically significant in the labeled cash transfer alone group). There are no statistically significant differences between the labeled cash transfer alone and labeled cash transfer plus personalized information groups. Children in Ethiopia have historically performed very poorly on these measures, particularly minimum dietary diversity; these improvements of more than 50 percent are both generally large and especially important in this context.

Household spending

Table 8 shows overall changes in spending due to the interventions that are consistent with the previous results: spending on eggs in the past month increased by 9 to 15 birr (45 to 75

[i] Another major food item to demonstrate positive and statistically significant effects was bread/pasta. The number of days in the past week that index children in the labeled cash transfer groups consumed bread or pasta increased by about 60 percent compared to the control group at baseline. While not necessarily the ideal change from a nutrition perspective, it is not surprising that children in the labeled cash transfer group consumed more bread and pasta. These are items that are typically purchased, rather than produced at home, and therefore more expensive. As a result, there is a perception that the "poorest" eat grain foods, while those with a bit more resources substitute into bread and pasta.

Table 8

Program Impact on Household Spending in the Last 30 Days

Dependent variable	eggs	meat/fish	legumes	all food	all non-food
Specification:	(1)	(2)	(3)	(4)	(5)
PI x Endline	1.322	11.575	0.503	20.395	45.409
	(1.495)	(15.232)	(9.003)	(35.239)	(70.918)
LCT x Endline	15.333***	32.059**	-1.772	82.622**	97.958
	(2.06)	(15.432)	(8.594)	(32.385)	(69.165)
PI x LCT x Endline	8.884***	33.293**	10.857	96.258***	-40.201
	(2.21)	(14.197)	(8.432)	(36.957)	(72.441)
Endline	4.024	17.666	-5.754	33.293	62.341
	(5.171)	(35.082)	(22.18)	(93.654)	(133.523)
Mean control group (BL)	2.879	47.532	86.032	392.589	262.774
No. households	498	498	498	498	498
R-squared	0.654	0.690	0.736	0.780	0.706
p-values associated with tests of equality					
(a) PI = LCT	0.000	0.174	0.794	0.049	0.274
(b) PI = PI x LCT	0.000	0.109	0.233	0.043	0.142
(c) LCT = PI x LCT	0.013	0.927	0.109	0.688	0.009
(d) F-test (all coeff's = 0)	0.000	0.238	0.240	0.073	0.033

Notes: Coefficients from main regression model are reported, with robust standard errors in parentheses. All specifications include controls for the household characteristics listed in Table 6 interacted with an indicator for endline, as well as the index child's age and gender and controls for the household's previous treatment group, all interacted with an indicator for endline. Each column corresponds to a separate specification, with the indicated dependent variables corresponding to spending on each item/category in the last month (measured in birr). Non-food includes spending on health, soap/detergent, school fees, clothes/shoes, and transportation. ***p<0.01, **p<0.05, *p<0.1

cents)[i] in the cash transfer treatment groups, a very large effect compared to a baseline mean of 2.9 birr (about 14 cents, roughly the cost of 1.4 eggs) in the control group at baseline. Spending on meat or fish also increased by about 68 percent.

Overall, accounting for baseline levels, total food spending in the cash transfer groups is about 80 birr higher than in the control group, as shown in the fourth column of Table 8. This suggests that, if we assume equal allocation of the cash transfer over the 6 weeks between baseline and endline, about a quarter of the 150 birr of the cash transfer either leaked into other non-food spending or was retained as savings. (Note that the 80 birr is measured over 30 days, whereas the 150 birr was distributed over 6 weeks. If we assume equal allocation across the 6 weeks, spending on food is estimated to increase by about 120 birr.) The last column of Table 8, showing no significant effects on spending on non-food items such as health expenses or transportation, provides suggestive evidence that much of the leakage of the cash transfer was into savings rather than spending on other non-food items.[ii]

The full set of analyzed spending groups are shown in Tables 18 and 19 of the supplementary materials for food spending and non-food spending, respectively, with patterns that are consistent with reported changes in food consumption.

Index child anthropometrics

As shown in Table 9, all three treatment groups show statistically significant improvements of about 0.1 standard deviations in weight-for-age z-scores. The coefficients on the other standardized anthropometric measures, weight-for-height z-scores and height-for-age z-scores, are generally positive and mostly insignificant.

[i] Equivalent to about 9 to 15% of the cash transfer, when scaled per day.
[ii] About 20 percent of households in the LCT groups reported not having spent all of the cash transfer by the time of the endline survey, with an average of 30 (of 150) birr remaining.

Table 9
Program Impact on Index Child Anthropometrics

Dependent variable Specification:	Weight-for-age z-score (1)	Weight-for-height z-score (2)	Height-for-age z-score (3)
PI x Endline	0.134***	0.136	0.056
	(0.036)	(0.1)	(0.114)
LCT x Endline	0.116***	-0.018	0.227*
	(0.042)	(0.106)	(0.117)
PI x LCT x Endline	0.102**	0.148	0.075
	(0.048)	(0.131)	(0.159)
Endline	-0.055	-0.723**	1.016***
	(0.126)	(0.307)	(0.375)
Mean control group (BL)	-1.090	-0.242	-1.705
No. children	498	497	497
R-squared	0.961	0.831	0.818
p-values associated with tests of equality			
(a) PI = LCT	0.665	0.155	0.180
(b) PI = PI x LCT	0.562	0.928	0.904
(c) LCT = PI x LCT	0.794	0.230	0.368
(d) F-test (all coeff's = 0)	0.826	0.297	0.381

Notes: Coefficients from main regression model are reported, with robust standard errors in parentheses. All specifications include controls for the household characteristics listed in Table 6 interacted with an indicator for endline, as well as the index child's age and gender and controls for the household's previous treatment group, all interacted with an indicator for endline. All z-scores were calculated using the Stata command zscore06, which uses 2006 WHO child growth standards as the comparison group. ***p<0.01, **p<0.05, *p<0.1

Secondary analyses

In Table 10, we analyze the impact of the interventions on the index child's 7-day egg consumption, stratifying the analyses by three child characteristics. The first two columns show the regressions stratified by whether the index child was above or below the median height-for-age z-score at baseline; the second two columns show the regressions stratified by whether the index child was above or below the median weight-for-age z-score at baseline; the final two columns show the regressions stratified by the index child's sex. In Table 20 of the supplementary materials, I report the same table with an indicator for minimum dietary diversity as the outcome. In general there is not a clear pattern of stronger effects for one group over the other. On the other hand, the last two columns, stratifying by the index child's sex, suggest that effect sizes are larger for girls than boys. Moreover, it appears that the majority of the overall effect seen on egg consumption in the personalized information alone group is being driven by improvements for girls.

We also explore whether caregivers' self-reported outcomes could be internally consistent. Specifically, we analyze whether the amount the caregivers reported that the index child consumed in eggs could plausibly be supported by the amount that the caregiver reports spending on eggs. Figures 19 and 20 of the supplementary materials show that these results are consistent within a household. The reported amount spent on eggs matches closely with the reported amount the index child consumed eggs; stratifying by whether the household owns an egg-producing hen makes the relationship more clear.

Mechanisms

Table 11 provides suggestive evidence about which hypothesized mechanisms are more or less likely to be relevant in producing the estimated effects shown above. In each

Table 10
Stratified Program Impact on Index Child Egg Consumption

Dependent variable Specification:	BL HAZ < median (1)	BL HAZ > median (2)	BL WAZ < median (3)	BL WAZ > median (4)	Boys (5)	Girls (6)
PI x Endline	0.280*	0.175	0.175	0.306	0.086	0.486**
	(0.156)	(0.199)	(0.142)	(0.189)	(0.15)	(0.19)
LCT x Endline	0.592***	0.608**	0.696***	0.510*	0.629**	0.713***
	(0.209)	(0.305)	(0.249)	(0.29)	(0.27)	(0.271)
PI x LCT x Endline	0.769***	0.661**	0.828***	0.570**	0.731***	0.874***
	(0.186)	(0.309)	(0.215)	(0.283)	(0.198)	(0.317)
Endline	-0.272	0.227	-0.526	0.568	-0.37	0.337
	(0.484)	(0.878)	(0.607)	(0.858)	(0.63)	(0.775)
Mean control group (BL)	0.333	0.379	0.323	0.387	0.439	0.259
No. children	249	249	245	254	261	238
R-squared	0.749	0.609	0.722	0.617	0.718	0.605
p-values associated with tests of equality						
(a) PI = LCT	0.163	0.135	0.043	0.468	0.040	0.407
(b) PI = PI x LCT	0.010	0.121	0.002	0.365	0.000	0.208
(c) LCT = PI x LCT	0.460	0.890	0.655	0.870	0.724	0.659
(d) F-test (all coeff's = 0)	0.030	0.144	0.004	0.563	0.001	0.384

Table 10 (continued)

Notes: Coefficients from main regression model are reported, with robust standard errors in parentheses. All specifications include controls for the household characteristics listed in Table 6 interacted with an indicator for endline, as well as the index child's age and gender and controls for the household's previous treatment group, all interacted with an indicator for endline (the control for gender drops out in the last two specifications). The outcome in all columns is the number of days in the past week that the index child consumed eggs. The first two specifications stratify by whether the index child's baseline HAZ was above or below the sample median (-1.61). The second two specifications stratify by whether the index child's baseline WAZ was above or below the sample median (-1.05). The last two specifications stratify by the sex of the index child. ***$p<0.01$, **$p<0.05$, *$p<0.1$

Table 11

Program Impact on Index Child Egg Consumption in the Last 7 Days - Mechanisms

Dependent variable	eggs (days)		eggs (days)		eggs (days)		eggs (days)
Specification:	(1)		(2)		(3)		(4)
PI x Endline x Caregiver controls money	0.182 (0.217)	PI x Endline x Caregiver attended school	-0.154 (0.263)	PI x Endline x Budgetary strain	0.138 (0.255)	PI x Endline x Information is worse	-0.271 (0.253)
LCT x Endline x Caregiver controls money	0.741** (0.358)	LCT x Endline x Caregiver attended school	-0.794** (0.337)	LCT x Endline x Budgetary strain	0.794** (0.364)	LCT x Endline x Information is worse	0.098 (0.337)
PI x LCT x Endline x Caregiver controls money	-0.006 (0.344)	PI x LCT x Endline x Caregiver attended school	0.118 (0.345)	PI x LCT x Endline x Budgetary strain	-0.485 (0.334)	PI x LCT x Endline x Information is worse	0.607 (0.372)
PI x Caregiver controls money	-0.006 (0.174)	PI x Caregiver attended school	0.118 (0.236)	PI x Budgetary strain	-0.485 (0.185)	PI x Information is worse	0.607 (0.207)
LCT x Caregiver controls money	-0.006 (0.52)	LCT x Caregiver attended school	0.118 (0.957)	LCT x Budgetary strain	-0.485 (0.507)	LCT x Information is worse	0.607 (0.633)
PI x LCT x Caregiver controls money	-0.006 (0.741)	PI x LCT x Caregiver attended school	0.118 (1.488)	PI x LCT x Budgetary strain	-0.485 (0.187)	PI x LCT x Information is worse	0.607 (1.398)
Endline x Caregiver controls money	-0.123 (0.15)	Endline x Caregiver attended school	0.279* (0.164)	Endline x Budgetary strain	-0.079 (0.17)	Endline x Information is worse	-0.113 (0.144)
Mean control group (BL, caregiver does not control money)	0.195	Mean control group (BL, caregiver did not attend school)	0.410	Mean control group (BL, no budgetary strain)	0.453	Mean control group (BL, Beliefs equal or above reality)	0.122
No. children	498	No. children	498	No. children	498	No. children	498
R-squared	0.662	R-squared	0.663	R-squared	0.667	R-squared	0.662
p-values associated with tests of equality							
(a) PI = LCT	0.127	(a) PI = LCT	0.083	(a) PI = LCT	0.090	(a) PI = LCT	0.323

Table 11 (continued)

(b) PI = PI x LCT	0.601	(b) PI = PI x LCT	0.473	(b) PI = PI x LCT	0.068	(b) PI = PI x LCT	0.023
(c) LCT = PI x LCT	0.099	(c) LCT = PI x LCT	0.037	(c) LCT = PI x LCT	0.004	(c) LCT = PI x LCT	0.240
(d) F-test (all coeff's = 0)	0.211	(d) F-test (all coeff's = 0)	0.091	(d) F-test (all coeff's = 0)	0.014	(d) F-test (all coeff's = 0)	0.072

Notes: Coefficients from interaction terms in main regression model are reported, with robust standard errors in parentheses. All specifications include controls for the household characteristics listed in Table 6 interacted with an indicator for endline, as well as the index child's age and gender and controls for the household's previous treatment group, all interacted with an indicator for endline. 'Caregiver controls money' indicates that caregiver or caregiver with head of household usually decide how money is spent, at baseline. 'Budgetary strain' is defined as having at least one of: (1) borrowed money in previous 6 weeks, or (2) unexpected expenses in the past month, at baseline. 'Information is worse' indicates that the information provided during the PI treatment was worse than the caregiver's prior beliefs. ***p<0.01, **p<0.05, *p<0.1

specification, the number of the days in the past week that the index child consumed eggs is the outcome, with coefficients on the interactions with each of the four characteristics described above reported. First, the cash transfer (alone) is more influential in cases where the caregiver controls the money, in line with the hypothesized effect. Second, the cash transfer is less effective when the caregiver has some education, consistent with a scenario where more educated women were already providing relatively improved diets for their children. The third specification, considering differential effects by budgetary strain, suggests that the cash transfer is especially effective when there is a particular degree of budgetary strain. Finally, the last column shows that the effects do not appear to be related to whether or not the caregiver found out that her child was doing worse than she previously believed.

Discussion

Nearly half of the world's annual 3.1 million deaths of children under 5 years are caused by malnutrition.[2] While rates of malnutrition have been falling throughout the developing world, the decrease has been significantly slower than established targets, including in Ethiopia. A range of factors contribute to malnutrition, and households have varying degrees of control over these factors. Existing evidence suggests, however, that many caregivers fail to take actions that would reduce malnutrition, even over things that they seemingly have some influence and knowledge. This study was designed to assess whether some dimensions of this inaction are due to behavioral factors and whether greater action can be induced with inexpensive "nudges" (potentially paired with small amounts of money), ultimately providing policy-relevant implications.

The main results suggest that the provision of personalized information led to important and meaningful change on some relevant outcomes, including the index child's consumption of

some protein rich foods and their age- and gender-standardized weight. These results suggest that providing this personalized information could be an important complement to existing nutrition-related interventions. In general, the labeled cash transfer intervention appears to have been more effective, with meaningful impacts on key outcomes such as consumption of protein-rich foods that were available in the community. These findings provide valuable evidence toward assessing how financial barriers influence malnutrition, something Bhutta, et al. (2013) described as "urgently needed" in leading off the *2013 Maternal and Child Nutrition* Lancet series.[2] In general, it does not appear that adding the personalized information intervention to the labeled cash transfer increased effect sizes in statistically meaningful ways.
Secondary analyses provided useful insights into what subgroups benefited most and what mechanisms are most likely be relevant. For example, it does not in general appear that more vulnerable children benefit more. And, unsurprisingly, the effects are most pronounced in cases where the caregiver is relatively empowered and feels that she exerts some control over the household's money.

While the labeled cash transfers were, overall, highly successful in achieving the desired behavioral changes, there are several other factors that are important to consider about these types of interventions. First, while labeling the money may be the most effective way to tie the money to behaviors that more directly influence malnutrition (e.g., food consumption versus growth monitoring checkups) and is a relatively low-cost approach from an implementation perspective, labeling may be inadequate from a political economy perspective. Wealth redistribution schemes (i.e., giving money away) may only retain public support if they require some conditions to be met by the recipients. Second, identifying a means for classifying which individuals, households, or communities are eligible for the cash transfer is challenging and creates an opportunity for gaming the system by those who are relatively well off.[17] As Fiszbein and Schady (2009) note, however, there are valuable spillover effects in domains such as management and transparency that may occur as a result of overcoming these types of implementation challenges.[17] Finally, CCTs and LCTs are only as effective as the complementary services that are available. There is a limit on improvements in child health if, for example, sanitation and hygiene remain inadequate, regardless of how much nutritional intake improves.

There are also some important weaknesses specific to this study to consider. First, most outcomes are self-reported, and households in the treatment groups were clearly not blinded to their treatment. On the other hand, enumerators were blinded to the households' treatment status during the baseline survey (the treatment(s) were only revealed after the end of the electronic data collection), as well as fully blinded during the endline survey (until questions specific to the treatment were asked), mitigating concerns about prompting by the enumerators.

Additionally, there were only 6 weeks between the baseline and endline surveys. While there are important treatment effects, it is not possible to determine whether the treatments have a longer-term influence from this pilot intervention – and, at times, there may be effects that take longer to present (see, for example, Evans, et al., 2016).[38] Evidence from previous cash transfer interventions showing long-term effects (e.g., Macours, et al. 2012) provides some encouraging evidence that longer-term effects are plausible.[39]

Overall, this study provides important insights into measures that can be taken to nudge caregivers into beneficial behaviors that have been shown to improve children's nutritional status (i.e., physical growth). Given that there have been only limited increases in donor aid for nutrition since 2008,[40] it is valuable to better understand means for increasing the effects of existing interventions. Future studies will be important to understand important nuances that remain unanswered after this study, including the sustainability of these effects.

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Chapter 1 Supplementary Materials

Definition of medical claims samples

Sample	Definition
Mother	*ICD9-CM Diagnoses* Outcome of delivery: V27.0, V27.1, V27.2, V27.3, V27.4, V27.5, V27.6, V27.7, V27.8, V27.9 Normal delivery: 650 *ICD9-CM Procedures* Forceps: 720, 721, 7221, 7229, 7231, 7239, 724, 726 Breech extraction: 7251, 7252, 7253, 7254 Vacuum extraction: 7271, 7279 Other specified and unspecified delivery: 728, 729 Internal and combined version and extraction: 7322 Other manually assisted deliveries: 7359 Episiotomy: 736 Cesarean section: 740, 741, 742, 744, 7499 *DRGs* complicated cesarean: 370 uncomplicated cesarean: 371 complicated vaginal delivery: 372 uncomplicated vaginal delivery: 373 uncomplicated vaginal delivery with sterilization and/or dilatation & curettage: 374 vaginal delivery with operation room procedure except sterilization and/or dilatation & curettage: 375
Neonate	*Newborn record criteria* MDC: 15 DIAGNOSES: 740-779 (and all subcategories) V29-V39 (and all subcategories) *Birth record criteria* MDC: 15 Admit type: 4 (newborn, the patient is born in the hospital OR no more than three days prior to the hospitalization)

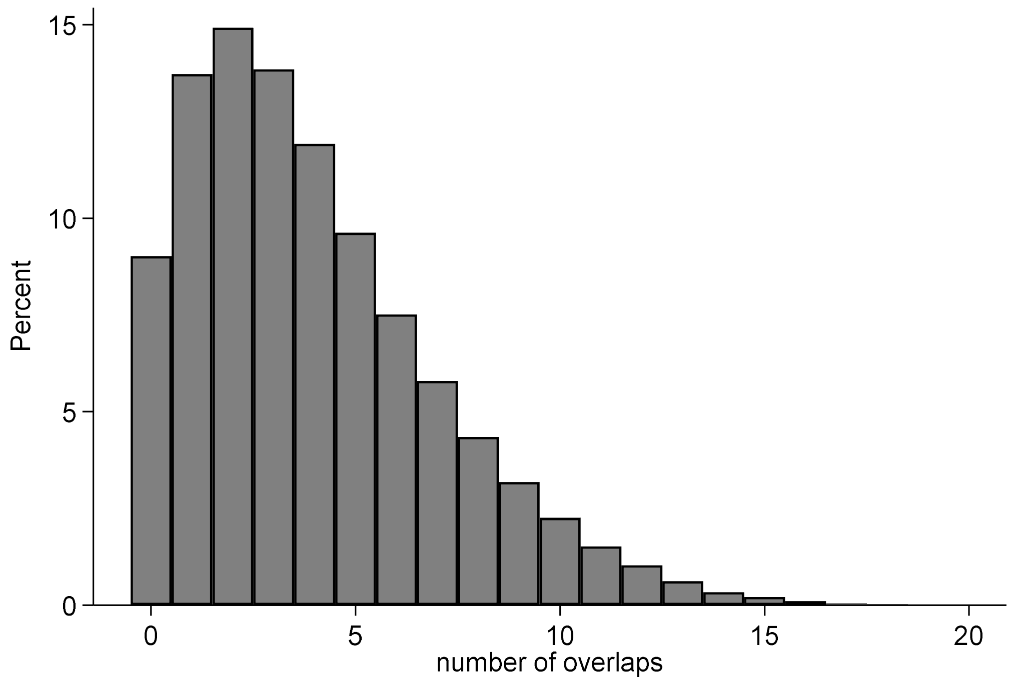
Definition of covariates, outcomes, and exposure

Covariate	Definition
Abnormal indications	Indicator for any of abnormal presentation, preterm, fetal death, and multiple gestation; ICD-9-CM diagnosis codes 64420, 64421, 65100, 65101, 65103, 65110, 65111, 65113, 65120, 65121, 65123, 65130, 65131, 65133, 65140, 65141, 65143, 65150, 65151, 65153, 65160, 65161, 65163, 65180, 65181, 65183, 65190, 65191, 65193, 65220, 65221, 65223, 65230, 65231, 65233, 65240, 65241, 65243, 65260, 65261, 65263, 65640, 65641, 65643, 66050, 66051, 66053, 66230, 66231, 66233, 66960, 66961, 67810, 67811, 67813, 7615, V271, V272, V273, V274, V275, V276, or V277
Age (mother)	Recorded in mother claims records
Breech procedures	ICD-9-CM procedure codes 7251, 7252, 7253, or 7254
Low risk	Defined by the Agency for Healthcare Research and Quality: cases excluding abnormal indications, breech procedure, or a previous Cesarean
Payer	Recorded in mother claims records (categorized as self-pay or charity/indigent care, Medicare, Medicaid, Blue Cross, commercial/employer, government, and unknown)
Previous cesarean	ICD-9-CM diagnosis codes 65420, 65421, or 65423
Race (mother)	Recorded in mother claims records (categorized as Asian alone, Black alone, other, unknown, or White alone)

Outcome	Definition
Admission to the NICU	Recorded on the birth certificate
Birth injury	ICD-9-CM diagnosis codes 7672 or 7674-7679
Cesarean delivery	DRG or MS-DRG payment codes 370, 371, 765, or 766 or ICD-9-CM procedure codes 740, 741, 742, 744, or 7499 without hysterectomy (IDC-9-CM procedure code 7491)
Five minute APGAR score < 7	Recorded on the birth certificate
Infection (maternal)	Indicator for any of chorioamnionitis (ICD-9-CM diagnosis codes 658.4, 658.40, 658.41, 658.43, or 762.7), endometritis (670, 670.00, 670.02, 670.04, 670.1, 670.10, 670.12, 670.14, 672, 672.00, 672.02, or 672.04), or wound infection (674.3, 674.30, 674.32, or 674.34) in cases of cesarean deliveries
Low birth weight	Indicator for birth weight < 2,500 grams, as recorded on the birth certificate
Postpartum hemorrhage	ICD-9-CM diagnosis codes 285.1, 666, 666.0, 666.00, 666.02, 666.04, 666.1, 666.10, 666.12, 666.14, 666.2, 666.20, 666.22, 666.24, 666.3, 666.30, 666.32, or 666.34
Prolonged length of stay	Indicator for a length of stay greater than 2 days for a vaginal delivery and greater than 4 days for a cesarean delivery; length of stay recorded in mother claims records
Seizure (neonate)	ICD-9-CM diagnosis codes 7790 or 7803
Severe perineal laceration	3rd or 4th degree injuries after a vaginal delivery: ICD-9-CM diagnosis codes 664.2, 664.20, 664.21, 664.24, 664.3, 664.30, 664.31, 664.34, 664.60, 664.61, or 664.64

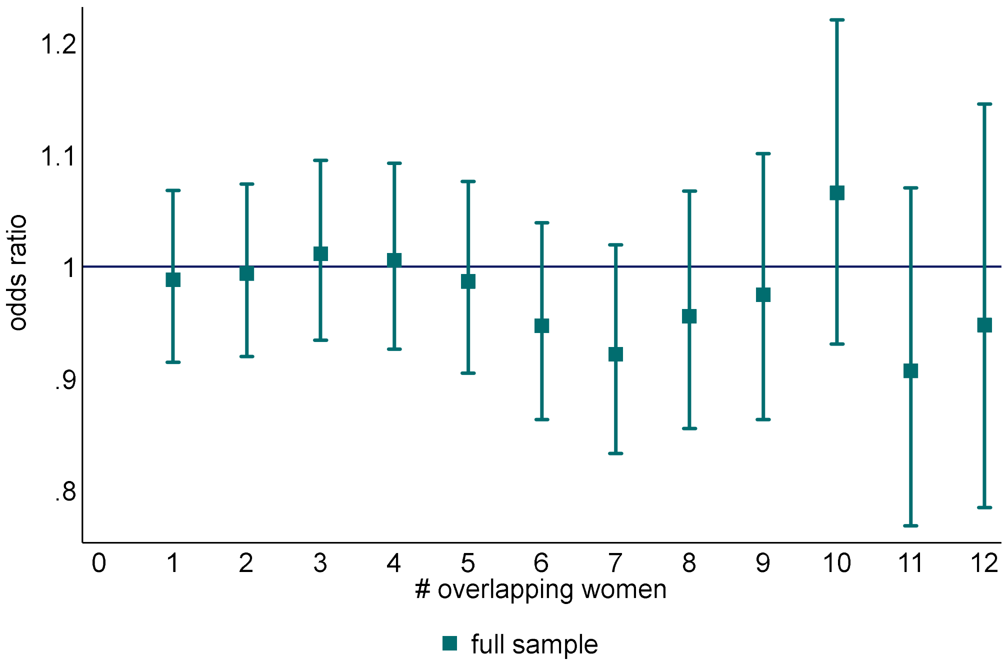
Exposure	Definition
Overlaps	Number of other women who, based on the combination of their birth certificate and claims records, are between their labor floor admission and delivery during the 6 hours prior to the index case birth, or the time between admission and delivery of the index case, whichever is shorter

Figure 13



Notes: The distribution of number of overlapping women in the sample is shown. The number of overlapping women is an indicator of the "busyness" of the labor floor, and is measured the number of other women on the labor floor between the index woman's time of delivery and the previous six hours, or between the index woman's time of arrival and time of delivery, whichever is shorter. The highest 0.01% of cases is trimmed. The median number of overlaps is 3, mean is 3.86, and 90^{th} percentile is 8.

Figure 14



Notes: the odds ratios comparing each number of overlapping women, in the six hours prior to birth, to zero overlapping women, adjusted for key covariates, are shown with 95% confidence intervals. Outcomes and covariates are measured using claims and birth certificate data; specific definitions are described in the supplementary materials.

Chapter 2 Supplementary Materials

Education poster used during QPM targeting meeting – November 2015

Label used for earmarking bags and bowls

QPM targeting messages at baseline – July/August 2015

- As you may remember from a few months ago when you were offered QPM, these improved maize varieties are more nutritious because they have more available protein, which is important for height, weight, health, and learning. They are very similar to typical maize varieties in other ways though, including how they are cultivated and how they can be prepared into food.

- Young children, especially those under three years old, are vulnerable to nutritional deficiencies that can lead to malnutrition, so it is important to specifically target your QPM to them. With improved protein intake, children grow taller and gain weight faster, learn better, and are less likely to get sick. This will also help them to be healthier and more productive as adults.
- Because of the benefits of QPM for young children in particular, it is useful to keep the maize separate for them and to only use it for feeding your very young children who are three years old and younger. This includes green maize.
- In particular, you should avoid selling your QPM or feeding it to chickens or other livestock. Whenever you have a choice, feed your QPM to your young children, rather than the adults in your household. By taking these steps, you can be sure to have enough QPM to feed to your young children for a long time.
- In order to target your QPM to your young children, you will need a way to keep your QPM separate from the rest of your maize once it is harvested. To do this, your household will need to either partition your maize crib or build a separate one before the harvest begins.
- Later this year, we will also provide you with a separate special bag for storing QPM grain and one for storing QPM flour, as well as markers to indicate which of your grain bags in storage contain QPM. This will help you keep track of which grain should be targeted specifically to your children who are three years old and younger. We'll also discuss strategies for preparing separate foods for your young children at that time.

QPM targeting group meetings – November 2015

Greetings & Introductions (5 minutes)

Materials
- Attendance sheet
Key Points
- *Introduce yourself (and participants)* - *Warmly welcome all participants and thank them for coming* - Today I'd like to talk to you about the QPM we gave you earlier this year and the importance of feeding this specifically to your young children. - At the end of today's meeting we will give you some tools to help you target the QPM to your young children and ensure that they are eating enough of it.
Action Items
- Check off attendance, record date - Ensure there are only women from your list present in the group; politely ask others to leave - Send partner to retrieve others if missing women from list

Educational Messages(10 minutes)

Materials
n/a
Key Points
- **Growth and nutrition are important**

- First I'd like to take some time to discuss the importance of growth and nutrition, especially for young children.
- Proper nutrition during the first few years of life is important for optimal growth, health, and development.
- It is difficult to compensate later in life for the consequences of early-life poor nutrition.
- Protein is especially important for children's growth, health, school performance, and learning ability
- Some foods, like meat, milk, eggs, beans, and peas, have good protein and should be fed to children.

- **QPM has protein and is especially good for young children**
  - However, sometimes infants and small children may not be able to eat these foods every day.
  - Therefore, we are trying to make everyday food have stronger protein. Quality protein maize is one of these everyday foods with better protein.
  - QPM is especially good for children, and it is especially important that they eat foods made from it.
  - Therefore we want to encourage you to specifically feed QPM to your youngest children, and offer you some guidance and materials to help you do this.

- **Keeping QPM separate and using it to cook for your young children is important**
  - It is very important that you keep QPM separate from your other maize and other grains so that you know specifically when you have cooked with QPM. It is

important to keep QPM separate from your conventional maize at all the different stages:

  - During planting
  - During harvest
  - While transporting maize from fields to home or storage cribs
  - While shelling
  - While storing grain in bags
  - Bringing to and from the mill
  - While storing flour before cooking
  - While cooking
  - Finally, while eating

- To help with storing the grain and flour separately, we will share with you today:
  - 4 special storage bags for grain
  - 1 special storage bag for flour
- As often as you can, you should cook foods with QPM specifically for your young children. For example, porridge is especially good to make with QPM to serve to young children.
- Similarly, whenever you cook foods with QPM, you'll want to take special care to make sure your young children eat enough of these foods.
  - To help ensure your young child eats enough of QPM-based foods, we are giving you this special plate that you should fill with these foods for him/her.

- **How to get kids to eat better**
    - Finally, I'd like to spend some time discussing how best to feed young children, to help with targeting QPM to them.
    - Babies and children have smaller stomachs, and can't eat as much at one time. As a result, they need small, frequent feeds.
    - Feed your child slowly and patiently, and encourage children to eat QPM-based foods, but do not force them.
    - Minimize distractions during meals if the child loses interest easily, especially when the child is eating QPM.
    - Congratulate the child when he/she eats QPM and finishes the food.
    - Feeding a child from his/her own plate helps, this will help you know if the child is getting enough of the QPM-based food.
    - To help you target QPM foods to your young children, we are sharing a special plate that you can use for feeding your young child. Whenever you make something with QPM, you can fill the plate for the child so you can be sure he/she has eaten the food.

Action Items
n/a

Group Discussion/Obstacles and How to Overcome Them (10 minutes)

Materials
n/a

Key Points

- Do you have any questions that we haven't already discussed?
- How will you need to work with your husband in order to be successful in targeting QPM to your young children?
- How do you think you will cook QPM for your young child/children? Porridge? Other foods?
- Is there anything that you think would be difficult to do that we haven't already discussed?
    ▪ How do you think we could overcome that obstacle?
    ▪ *Help women think about ways to overcome any obstacles they identify*

Action Items
n/a

Distribution of Materials (10 minutes)

Materials
- Grain and flour bags - Plates - Attendance sheet
Key Points
- Bags and plates are for your household to use, so please keep them and don't give them to anyone else

Action Items
- Distribute 4 grain bags, 1 flour bag, and 1 plate to each woman *on your pre-specified list* • *** Make sure to check people off the list*** - Record number of these items that each woman received on attendance sheet

QPM targeting messages at midline – February/March 2016

- Protein is especially important for young children's growth, health, school performance, and learning ability
- QPM has more protein than other maize and is especially good for children, so it is especially important that they eat foods made from it.
- Therefore we want to encourage you to specifically feed QPM to your youngest children, and gave you some tools to help you do this a few months ago, including flour and seed bags to keep QPM separate and special plates and spoons for feeding your young children.
- As often as you can, you should cook foods with QPM specifically for your young children. For example, porridge is especially good to make with QPM to serve to young children.
- Similarly, whenever you cook foods with QPM, you'll want to take special care to make sure your young children eat enough of these foods. You can use the special plates to help make sure your children have eaten enough.

Controls included in adjusted regressions

Household size

Household has high quality roof

Amount of land owned

Total maize produced during last year's major season

Caregiver age

Caregiver ever attended school

Caregiver's total number of pregnancies

Index child age

Index child sex

Index child had diarrhea in past two weeks (BL)

Index child had a cough or breathing problems in past two weeks (BL)

Index child had a fever in the past two weeks (BL)

Number of time caregiver received antenatal care during pregnancy with index child

Days the caregiver cooked for the index child in the last week (BL)

Days the caregiver cooked food with maize for the index child in the last week (BL)

Days the caregiver cooked food with QPM for the index child in the last week (BL)

Days the index child consumed food with QPM in the past week (BL)

Days the caregiver cooked porridge for the index child in the last week (BL)

Days the caregiver served fruit to the index child in the last week (BL)

Months the caregiver exclusively breastfed the index child

Caregiver worried about having enough food due to money, in the past 3 months (BL)

Index child height-for-age z-score (BL)

Index child weight-for-age z-score (BL)

Caregiver was present during QPM seed offer

Household has a telephone

Size of the household's community health group

Table 12 Baseline characteristics of the study participants

	QPM only Baseline sample (n=320)	QPM + targeting Baseline sample (n=290)	p-value
Household characteristics			
Number of household members	6.21 (1.99)	6.19 (2.17)	0.80
High quality roof*	0.60 (0.49)	0.53 (0.50)	0.07
Land owned (timad)*	5.60 (6.55)	5.43 (5.93)	0.67
Maize produced (kg)*	1744.24 (2336.62)	2034.36 (2385.70)	0.60
Caregiver characteristics			
Age (years)	28.43 (5.65)	28.30 (6.03)	0.97
Attended school	0.30 (0.46)	0.39 (0.49)	0.04
Number of pregnancies	4.45 (2.16)	4.35 (2.42)	0.86
Index child characteristics			
Age (months)	19.03 (7.88)	21.16 (8.89)	0.00
Male	0.56 (0.50)	0.47 (0.50)	0.06
Height-for-age (z-score)	-1.46 (1.34)	-1.25 (1.47)	0.07
Weight-for-age (z-score)	-1.05 (1.09)	-0.91 (1.14)	0.15
Health and health-seeking behavior			
Index child sick with diarrhea in past 2 weeks	0.19 (0.39)	0.17 (0.38)	0.50
Index child sick with cough/breathing problems in past 2 weeks	0.18 (0.39)	0.14 (0.35)	0.12
Index child sick with fever in past 2 weeks	0.21 (0.41)	0.18 (0.38)	0.17
Number times CG sought ANC during pregnancy with index child	3.22 (1.63)	3.28 (1.49)	0.75
Cooking & feeding			
Days in past week cooked specifically for young child	1.84 (2.26)	1.78 (2.28)	0.85
Days in past week cooked something with maize	5.64 (2.50)	5.71 (2.41)	0.99
Days in past week cooked something with QPM	0.12 (0.72)	0.23 (1.07)	0.25
Days in past week index child ate something with QPM	0.12 (0.72)	0.16 (0.84)	0.78
Days in past week cooked porridge and served to young child	0.76 (1.23)	0.76 (1.20)	0.47

Table 12 (continued)

Days in past week served fruit to young child	1.35 (1.67)	1.24 (1.73)	0.61
Months exclusively breastfed index child	5.20 (1.66)	5.08 (1.42)	0.45
Worried not enough food because not enough money, in last 3 mos.	0.39 (0.49)	0.36 (0.48)	0.43
Joint test of orthogonality F-statistic		2.27	0.00

Notes: The baseline sample is defined as all households where the caregiver survey was conducted at baseline. Means and standard deviations for each outcome are shown. P-values are derived from a regression of the outcome on an indicator for the QPM + targeting group, controlling for kebele (strata) and clustered at the 5 to 1 group level. Child height-for-age and weight-for age z-scores are normalized using the 2006 WHO growth standards. The joint test of orthogonality is a test of the null hypothesis that the coefficients on all characteristics in the table are jointly equal to zero, where the outcome is an indicator for the QPM + targeting group. *rows are measured through the household head survey, QPM only n = 318, QPM + targeting n = 285.

Table 13: Distribution of index child QPM consumption at midline and endline

Days consumed QPM last week	**QPM only mean (95% CI)**	**QPM + targeting mean (95% CI)**
Midline		
0	0.37 (0.32 to 0.43)	0.18 (0.14 to 0.23)
1	0.01 (0.00 to 0.03)	0.03 (0.01 to 0.05)
2	0.03 (0.01 to 0.05)	0.03 (0.01 to 0.05)
3	0.09 (0.06 to 0.12)	0.12 (0.08 to 0.16)
4	0.05 (0.02 to 0.07)	0.10 (0.06 to 0.14)
5	0.04 (0.02 to 0.06)	0.08 (0.04 to 0.11)
6	0.01 (0.00 to 0.03)	0.02 (0.00 to 0.04)
7	0.39 (0.34 to 0.45)	0.45 (0.39 to 0.51)
Endline		
0	0.49 (0.44 to 0.55)	0.42 (0.36 to 0.48)
1	0.00 (0.00 to 0.01)	0.01 (0.00 to 0.02)
2	0.05 (0.03 to 0.08)	0.06 (0.03 to 0.08)
3	0.05 (0.02 to 0.07)	0.08 (0.04 to 0.11)
4	0.04 (0.02 to 0.06)	0.08 (0.04 to 0.11)
5	0.03 (0.01 to 0.05)	0.03 (0.01 to 0.05)
6	0.01 (0.00 to 0.02)	0.01 (0.00 to 0.02)
7	0.33 (0.28 to 0.38)	0.33 (0.27 to 0.39)

Notes: QPM = Quality Protein Maize, CI = confidence interval. Underlying numbers to figure 7: the percent of index children falling into each category of days in the past week consumed QPM at midline and endline, with 95% confidence intervals in parentheses.

Table 14 Impact of the intervention package on consumption outcomes at midline and endline

	Mean at midline (SD)	Unadjusted		Adjusted	
		OR or IRR (95% CI)	**p-value**	**OR or IRR (95% CI)**	**p-value**
QPM					
Index child consumed any QPM in last 7 days					
QPM only	0.63 (0.48)				
QPM + targeting	0.82 (0.39)	2.96 (1.95 to 4.50)	0.00	2.77 (1.73 to 4.45)	0.00
Days index child consumed QPM last week					
QPM only	3.57 (3.13)				
QPM + targeting	4.46 (2.72)	1.27 (1.13 to 1.43)	0.00	1.22 (1.08 to 1.38)	0.00
Days index child consumed porridge with QPM last week					
QPM only	0.63 (1.09)				
QPM + targeting	1.15 (1.26)	1.87 (1.49 to 2.33)	0.00	1.68 (1.32 to 2.12)	0.00
Days index child consumed injera with QPM last week					
QPM only	2.66 (3.04)				
QPM + targeting	3.19 (3.03)	1.21 (1.03 to 1.43)	0.02	1.18 (0.99 to 1.41)	0.07
Days index child consumed quita with QPM last week					
QPM only	1.01 (1.63)				
QPM + targeting	1.47 (1.82)	1.52 (1.20 to 1.92)	0.00	1.59 (1.23 to 2.06)	0.00
Days index child consumed dabo with QPM last week					
QPM only	1.51 (2.01)				
QPM + targeting	1.91 (1.96)	1.29 (1.06 to 1.56)	0.01	1.22 (1.00 to 1.51)	0.05
Conventional maize					
Days index child consumed conventional maize last week					
QPM only	4.59 (3.01)				
QPM + targeting	4.22 (3.00)	0.90 (0.81 to 1.01)	0.07	0.91 (0.81 to 1.03)	0.13

Table 14 (continued)

	Mean at endline (SD)	Unadjusted Beta (95% CI)	Unadjusted p-value	Adjusted Beta (95% CI)	Adjusted p-value
QPM					
Index child consumed any QPM in last 7 days					
QPM only	0.51 (0.50)				
QPM + targeting	0.58 (0.49)	1.45 (0.97 to 2.16)	0.07	1.12 (0.73 to 1.73)	0.60
Days index child consumed QPM last week					
QPM only	2.90 (3.17)				
QPM + targeting	3.16 (3.07)	1.10 (0.93 to 1.31)	0.28	1.02 (0.86 to 1.21)	0.85
Conventional maize					
Days index child consumed conventional maize last week					
QPM only	5.14 (2.79)				
QPM + targeting	4.90 (2.85)	0.95 (0.86 to 1.04)	0.23	0.98 (0.88 to 1.08)	0.61

Notes: SD = standard deviation; CI = confidence interval; OR = odds ratio; IRR = incidence-rate ratio; QPM = Quality Protein Maize; odds ratios from logistic regressions are reported for binary outcomes; incident-rate ratios from poisson regressions are reported for count outcomes; unadjusted columns control for kebele (randomization strata) and are clustered at the 5 to 1 group level. Adjusted columns additionally control for all variables shown in Table 1 and whether the caregiver was present during the adoption encouragement, whether the household had a telephone number, and the size of the household's cluster (characteristics balanced during randomization).

Table 15A Impact of the intervention package on cooking, storage, etc. outcomes at midline

	Mean at midline (SD)	Unadjusted OR or IRR (95% CI)	Unadjusted p-value	Adjusted OR or IRR (95% CI)	Adjusted p-value
QPM storage and utilization					
QPM grain unmixed during storage					
QPM only	0.40 (0.49)				
QPM + targeting	0.83 (0.38)	8.88 (5.78 to 13.66)	0.00	9.01 (5.55 to 14.63)	0.00
QPM flour unmixed during storage					
QPM only	0.26 (0.44)				
QPM + targeting	0.74 (0.44)	8.71 (5.72 to 13.26)	0.00	9.42 (6.00 to 14.78)	0.00
Own QPM left					
QPM only	0.86 (0.35)				
QPM + targeting	0.92 (0.27)	1.82 (1.03 to 3.21)	0.04	1.34 (0.70 to 2.56)	0.38
Not sold QPM since beginning of season					
QPM only	0.92 (0.27)				
QPM + targeting	0.95 (0.22)	2.34 (1.06 to 5.18)	0.04	2.49 (0.98 to 6.33)	0.06
QPM cooking and consumption					
Cooked food specifically for young children					
QPM only	0.28 (0.45)				
QPM + targeting	0.33 (0.47)	1.31 (0.91 to 1.90)	0.15	1.33 (0.88 to 2.03)	0.18
Days cooked food specifically for young children					
QPM only	0.77 (1.52)				
QPM + targeting	1.08 (1.89)	1.39 (1.04 to 1.86)	0.03	1.36 (1.00 to 1.85)	0.05
Cooked QPM food specifically for young children					
QPM only	0.10 (0.30)				
QPM + targeting	0.25 (0.43)	3.38 (2.04 to 5.61)	0.00	3.30 (1.79 to 6.07)	0.00

Table 15A (continued)

Days cooked QPM food specifically for young children					
QPM only	0.21 (0.72)				
QPM + targeting	0.85 (1.69)	3.88 (2.43 to 6.19)	0.00	3.69 (2.21 to 6.17)	0.00

Notes: ^outcomes are measured at midline and endline; SD = standard deviation; CI = confidence interval; OR = odds ratio; IRR = incidence-rate ratio; QPM = Quality Protein Maize; odds ratios from logistic regressions are reported for binary outcomes; incident-rate ratios from poisson regressions are reported for count outcomes; unadjusted columns control for kebele (randomization strata) and are clustered at the 5 to 1 group level. Adjusted columns additionally control for all variables shown in Table 2 and whether the caregiver was present during the adoption encouragement, whether the household had a telephone number, and the size of the household's cluster (characteristics balanced during randomization).

Table 15B Impact of the intervention package on cooking, storage, etc. outcomes at endline

	Mean at endline (SD)	Unadjusted: OR or IRR (95% CI)	Unadjusted: p-value	Adjusted: OR or IRR (95% CI)	Adjusted: p-value
QPM storage and utilization					
QPM grain stored in intervention bag					
QPM only	0.04 (0.19)				
QPM + targeting	0.85 (0.36)	256.76 (84.42 to 780.95)	0.00	962.76 (179.14 to 5174.26)	0.00
QPM flour stored in intervention bag					
QPM only	0.04 (0.19)				
QPM + targeting	0.88 (0.33)	512.33 (146.24 to 1794.93)	0.00	3372.34 (301.23 to 37753.49)	0.00
QPM grain unmixed during storage					
QPM only	0.74 (0.44)				
QPM + targeting	0.95 (0.22)	6.82 (2.88 to 16.14)	0.00	12.14 (3.05 to 48.28)	0.00
QPM flour unmixed during storage					
QPM only	0.59 (0.49)				
QPM + targeting	0.87 (0.33)	5.23 (2.91 to 9.42)	0.00	8.01 (3.91 to 16.42)	0.00
Own QPM left					
QPM only	0.64 (0.48)				
QPM + targeting	0.69 (0.46)	1.39 (0.91 to 2.11)	0.13	1.14 (0.72 to 1.82)	0.57
Never sold QPM^					
QPM only	0.88 (0.32)				
QPM + targeting	0.91 (0.28)	1.90 (0.99 to 3.64)	0.05	2.04 (0.94 to 4.41)	0.07

Table 15B (continued)

QPM cooking and consumption					
Cooked food specifically for young children					
QPM only	0.25 (0.44)				
QPM + targeting	0.31 (0.46)	1.43 (0.98 to 2.08)	0.06	1.47 (0.95 to 2.29)	0.09
Days cooked food specifically for young children					
QPM only	0.74 (1.51)				
QPM + targeting	0.97 (1.76)	1.34 (0.98 to 1.84)	0.06	1.42 (1.03 to 1.98)	0.03
Cooked QPM food specifically for young children					
QPM only	0.12 (0.32)				
QPM + targeting	0.18 (0.38)	1.77 (1.09 to 2.88)	0.02	1.33 (0.78 to 2.28)	0.29
Days cooked QPM food specifically for young children					
QPM only	0.28 (0.90)				
QPM + targeting	0.49 (1.28)	1.78 (1.11 to 2.85)	0.02	1.52 (0.89 to 2.60)	0.12

Notes: ^outcomes are measured at midline and endline; SD = standard deviation; CI = confidence interval; OR = odds ratio; IRR = incidence-rate ratio; QPM = Quality Protein Maize; odds ratios from logistic regressions are reported for binary outcomes; incident-rate ratios from poisson regressions are reported for count outcomes; unadjusted columns control for kebele (randomization strata) and are clustered at the 5 to 1 group level. Adjusted columns additionally control for all variables shown in Table 2 and whether the caregiver was present during the adoption encouragement, whether the household had a telephone number, and the size of the household's cluster (characteristics balanced during randomization).

Chapter 3 Supplementary Materials

Scripts

General information script

Immediately following the baseline surveys with the index child's caregiver, the enumerators delivered a brief educational message to all households, adapted from UNICEF guidelines found at https://www.unicef.org/nutrition/files/counseling_cards_Oct._2012small.pdf. In delivering this message, the enumerators followed the following script, assisted by the visual guide shown in Figure .

Continue to breastfeed (until at least 2 years) and feed a variety of foods at each meal to your young child. For example:

- Animal source foods (meat, chicken, fish, liver), and eggs, milk, and milk products
- Staples (maize, wheat, rice, teff, and sorghum); roots and tubers (cassava, potatoes)
- Legumes (beans, lentils, peas, groundnuts) and seeds (sesame)
- Vitamin-A rich fruits and vegetables (mango, papaya, passion fruit, oranges, dark-green leaves, carrots, yellow sweet potato, and pumpkin) and other fruit and vegetables (banana, pineapple, watermelon, tomatoes, avocado, eggplant, and cabbage)

Maintain safe preparation and storage methods:

- Wash your hands with soap before preparing food, and before feeding your baby.
- Your baby's hands should be washed also.
- Wash your hands after changing nappies or going to the toilet.
- Wash all bowls, cups and utensils with clean water and soap. Keep covered before using.

- Prepare food in a clean area and keep it covered. A baby should have his or her own cup and bowl.
- Serve food immediately after preparation.

Other notes:

- Introduce animal source foods early to babies and young children and give them as often as possible. Cook well and chop fine.
- Additional nutritious snacks (extra food between meals) such as pieces of ripe mango, papaya, banana, avocado, other fruits and vegetables, boiled potato, sweet potato and fresh and fried bread products can be offered once or twice per day.
- Try to feed a variety of foods at each meal.
- Avoid giving sugary drinks or sweet biscuits.

Personalized information script

In households selected for the personalized information intervention, enumerators explained to caregivers about the index child's height quality using the visual in Figure 4 and script shown below.

- As you know, the quality of a child's nutrition during the first few years has a large impact on his/her schooling, health, and adult outcomes, and it is difficult to make up for poor growth later in life.
- In order to understand whether a child is receiving proper nutrition during his/her first few years, we often focus on the child's height.
- We focus on a child's height, rather than weight, as a measure of nutritional status since it reflects longer-term influences, especially the quality of the child's nutritional intake over time. Height is not influenced by recent illnesses or recent differences in food availability the way that weight might be.
- As you know, we have measured [INDEX CHILD]'s height and weight several times over the past year. Since it is sometimes difficult to know whether a child's height is appropriate given their age, I want to provide some additional guidance to you today about your child's height.
- Since children in different parts of the world may grow differently, I will show you information on how your child's height compares to other healthy children like those living in East Africa who are also boys/girls.

SHOW CARD WITH CHILD'S CURRENT HEIGHT EVALUATIONS

- As we discussed during the interview, this visual here is designed to visually show the quality of a child's height.
- Each of the five positions represents the relative rank of a child's height, *compared to other children who are the same age and gender from East Africa*.
    - For example, if a child was very short compared to other children her age and gender from East Africa, her height would be represented by this first position.
    - A child who was very tall compared to her peers would be represented by this last position.
    - Those who are about average would be represented by this middle space.
    - Those who are relatively short, but not the shortest, would be in the second position, and those who are relatively tall, but not the tallest, would be in the fourth position.

- Finally, I want to emphasize that if your child's current height is unsatisfactory, this is not indicative of an acute problem. Rather, you may want to consider how you can improve your child's growth going forward, and the health extension worker can help provide guidance. If our measurements of your child indicated an acute problem, we would have referred him/her to a health facility when we recently measured your child.
- Based on our recent measurements of your child, his/her current height, compared to other healthy East African children who are the same age and gender is <u>very satisfactory / somewhat satisfactory / neither satisfactory nor unsatisfactory / somewhat unsatisfactory / very unsatisfactory</u>.

Do you have any questions?

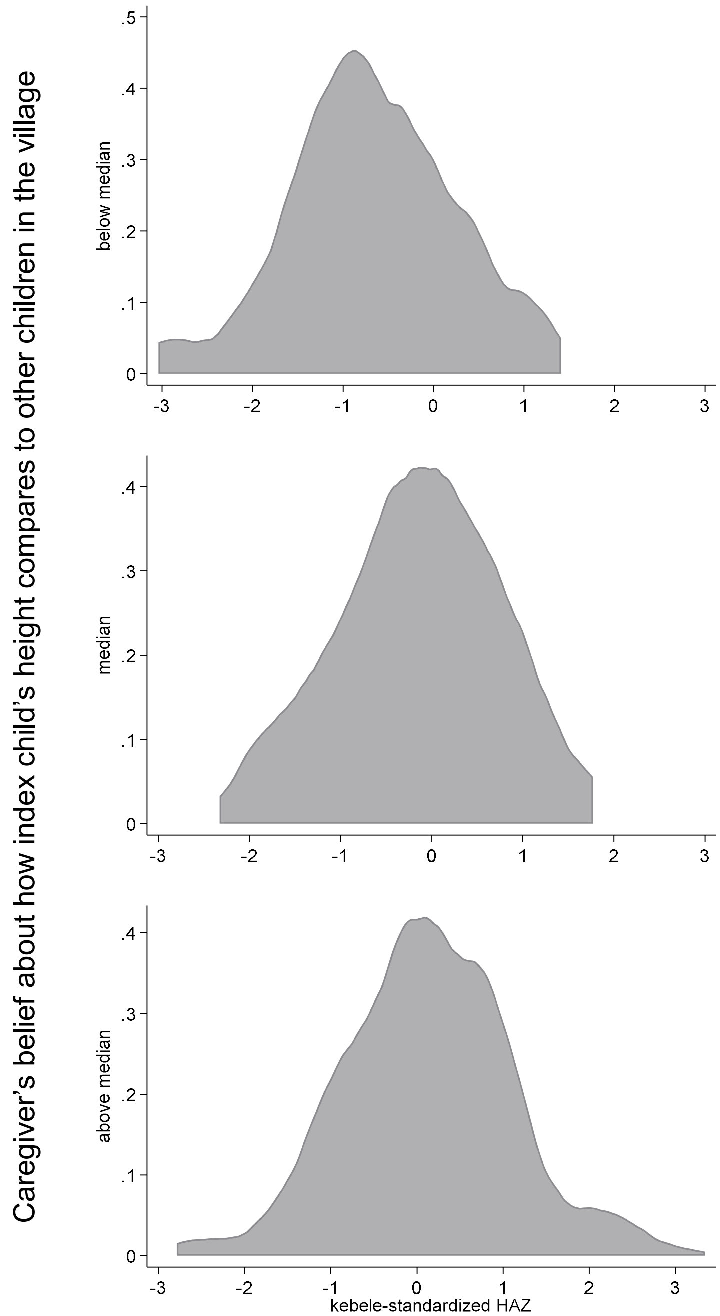
Labeled cash transfer script

In households selected for the labeled cash transfer intervention, enumerators found a private location and followed the following script when giving the 6 cash-filled envelopes to the caregivers.

- We know that it is sometimes difficult to afford the food that you would most like to feed [INDEX CHILD], so today I have a small cash transfer to offer you in order to buy a few more healthy foods for [INDEX CHILD] over the next 6 weeks.
- I have a total of 150 birr to offer to you, which has been evenly divided into these 6 envelopes. Each envelope has 25 birr. Each week, you should use the money in one envelope to purchase *additional* healthy foods for [INDEX CHILD] that you would not otherwise typically feed to the child. In other words, this money should not be used for foods that you already normally buy for [INDEX CHILD].
- For example, you may wish to purchase enough eggs to feed to the index child several times per week.
- To make it easier to keep track of the money, each envelope is numbered and has [INDEX CHILD]'s name. You should only open one envelope each week.
- It is important that you use this money *only* for purchasing healthy foods for [INDEX CHILD], so that he/she may grow a healthy amount over the next 6 weeks.
- You may also wish to use the money for purchasing foods for any other younger children in your household since it is also very important for these young children to consume healthy foods.
- Your household has been randomly selected to receive this one-time cash transfer, and there are no current plans to extend this cash transfer program in the future.

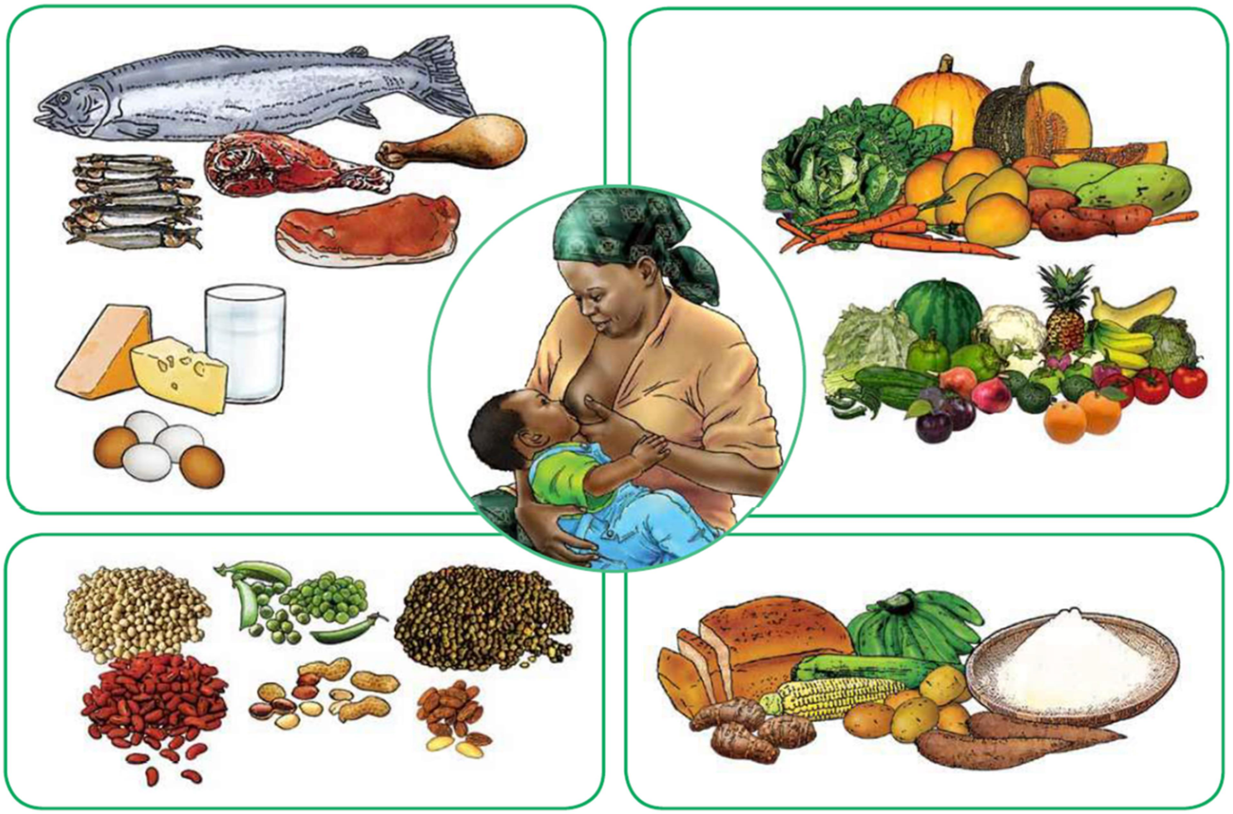
Do you have any questions?

Figure 15: Pre-intervention beliefs about child's height position



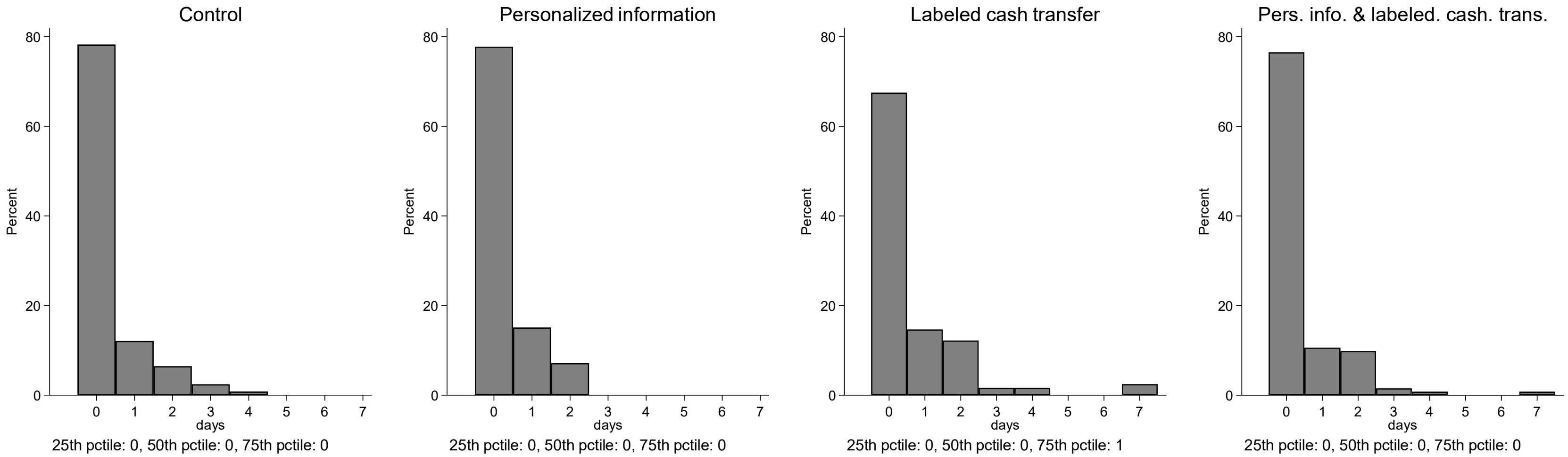
Notes: The distributions of height-for-age z-scores (HAZ) for all children (n=505), standardized by kebele, as measured in July 2016 are shown, separated by the caregiver's belief about how the child's height compares to other children in the village; on a 10 rung ladder, positions 1-4 are depicted as “below median”, 5 is depicted as “median”, and 6-10 are depicted as “above median”. 12%, 34%, and 54% of cases fall into each of the three bins.

Figure 16: General information visual guide



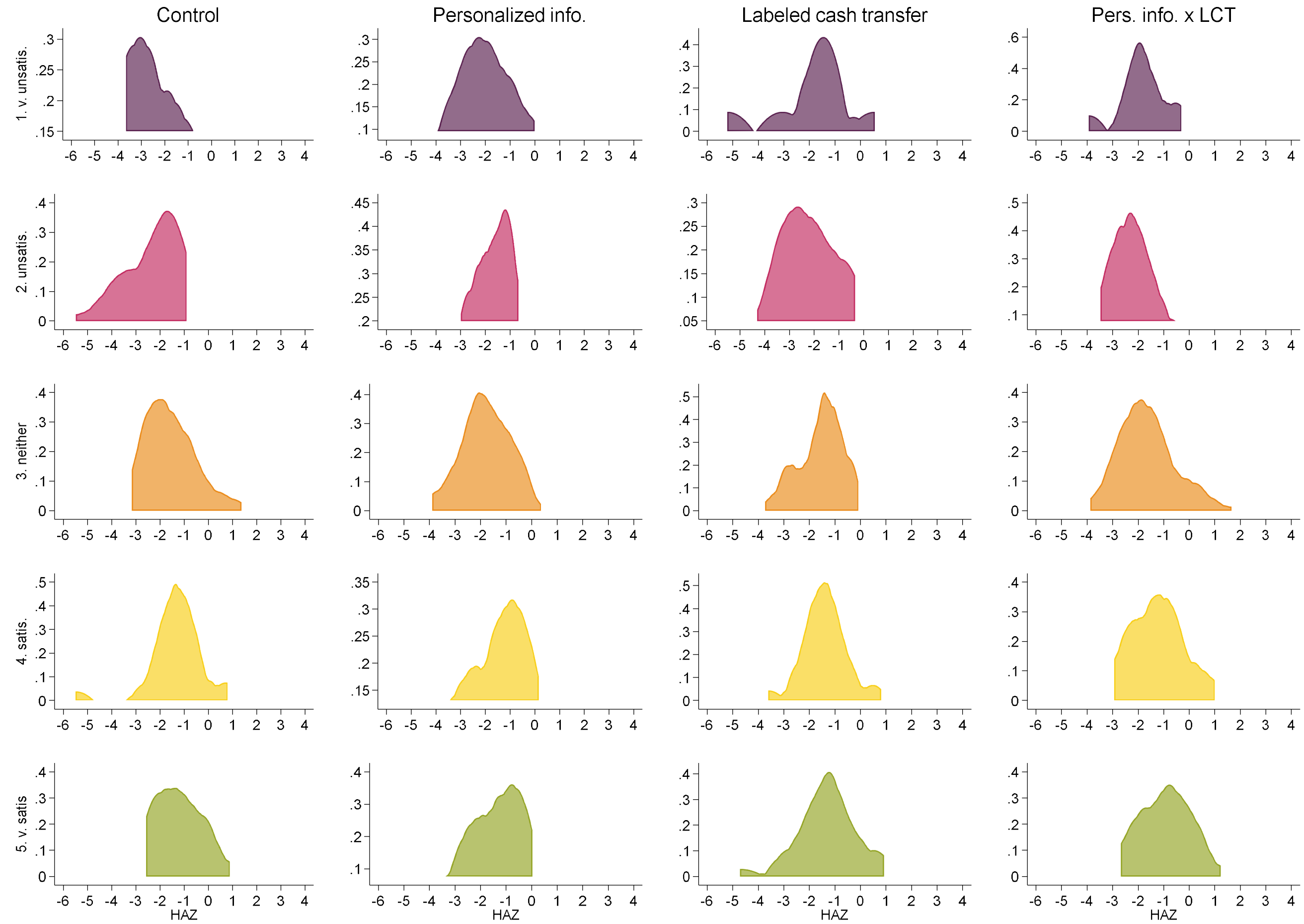
Notes: Immediately following the baseline surveys with the index child's caregiver, the enumerators delivered a brief educational message, assisted by a small poster with the above visual (source: https://www.unicef.org/nutrition/files/counseling_cards_Oct._2012small.pdf).

Figure 17: Distribution of baseline egg consumption



Notes: Caregivers were asked how many days in the past week the index child consumed eggs, with responses ranging from 0 to 7. The distributions of responses at baseline, by treatment group, are shown. The 25^{th}, 50^{th}, and 75^{th} percentiles of responses are shown below each distribution.

Figure 18: Baseline beliefs and actual HAZ scores, by treatment group



Notes: Distribution of height-for-age z-scores (HAZ) at baseline, broken down by caregivers' baseline beliefs about their child's height position ("very unsatisfactory" to "very satisfactory") and treatment group.

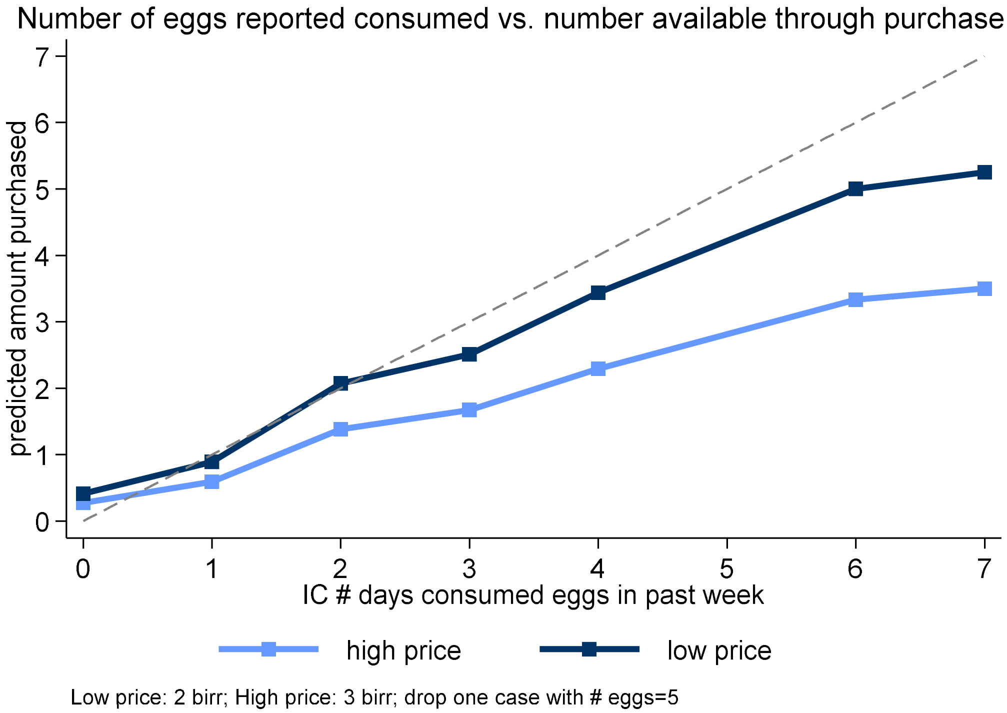
Figures 19 and 20 below show that reported spending and consumption are plausibly consistent. In both figures, the x-axis shows the reported number of days in the past week that the index child consumed eggs.[1] The y-axis shows the "predicted" number of eggs available through purchase by the household in the past week – calculated by dividing spending on eggs in the past 30 days by four (to get a rough weekly spending amount), and then dividing by the price of eggs.[2] The gray, dashed line in each figure is drawn at 45 degrees, indicating a case where the predicted number of purchased eggs available in the household per week exactly equals the number of days in the past week when the index child was reported to have consumed eggs.

Figure 19 shows the relationship between reported egg consumption days in the past week and predicted number of eggs purchased by the household for the lowest and highest prices reported for eggs (i.e., an upper and lower bound for number of available purchased eggs), and shows that responses on egg consumption and spending appear fairly consistent, especially if children are receiving at most one egg per day, as was found to be the case during focus groups and piloting prior to the intervention.

About a third of households reported owning a hen that was currently laying eggs at the time of the survey. In Figure 20, I again consider the relationship between reported days of egg consumption in the past week with predicted number of eggs purchased (using the median egg price), split by whether the household currently has an egg-laying hen. As expected, the predicted number of eggs purchased based on reported spending is higher for households without an egg-laying hen. Moreover, the predicted number of eggs purchased is almost always greater than days reported of index child egg consumption for these households – further corroboration of the internal consistency of respondents' self-reported spending and food consumption.

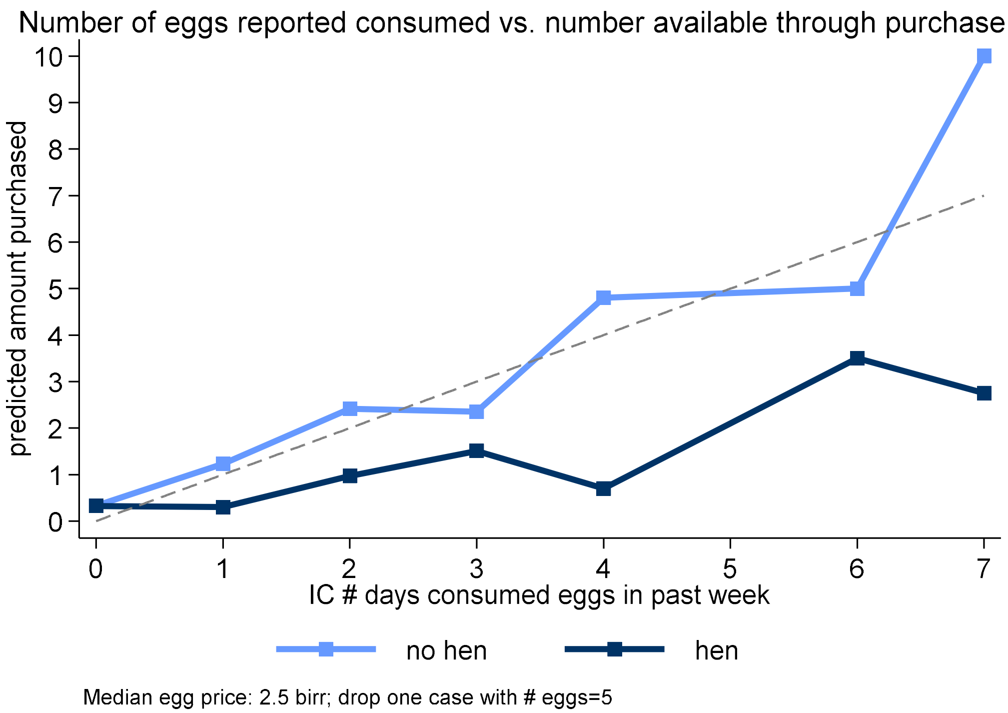
[1] Because only one respondent answered "5 days" in the past week, this observation was dropped when constructing the figures.
[2] Egg prices were collected from markets in each kebele during the baseline and endline surveys. Endline prices are used for this exercise to be consistent with the other values used in the figure.

Figure 19: Predicted number of eggs purchased vs. reported number of days index child ate eggs in past week – high and low bound on price (endline enly)



Notes: The x-axis shows the reported number of days in the past week that the index child consumed eggs. The y-axis shows the "predicted" number of eggs available through purchase in the household in the past week – calculated by dividing spending on eggs in the past 30 days by four (to get a rough weekly spending amount), and then dividing by the price of eggs. The gray, dashed line in each figure is drawn at 45 degrees, indicating a case where the predicted number of eggs exactly equals the number of days in the past week when the index child was reported to have consumed eggs. The two blue lines correspond to an upper and lower bound on number of eggs available through purchase, based on market prices collected during the endline survey.

Figure 20: Predicted number of eggs purchased vs. reported number of days index child ate eggs in past week – split by whether household owns egg-laying hen (endline only)



Notes: The x-axis shows the reported number of days in the past week that the index child consumed eggs. The y-axis shows the "predicted" number of eggs available through purchase in the household in the past week – calculated by dividing spending on eggs in the past 30 days by four (to get a rough weekly spending amount), and then dividing by the price of eggs. The gray, dashed line in each figure is drawn at 45 degrees, indicating a case where the predicted number of eggs exactly equals the number of days in the past week when the index child was reported to have consumed eggs. The two blue lines correspond to households that did and did not have an egg-laying hen at the time of the endline survey.

Table 16
Program impact on caregiver beliefs and concern

Dependent variable Specification:	Perception of child's position (1)	Discrepancy between perception of child position and actual position (2)	Concern about child's growth (3)
PI x Endline	-0.411***	-0.465***	-0.292
	(0.157)	(0.151)	(0.186)
LCT x Endline	-0.032	-0.152	0.044
	(0.154)	(0.144)	(0.171)
PI x LCT x Endline	-0.327**	-0.378**	0.093
	(0.163)	(0.159)	(0.172)
Endline	-0.421	-0.459	-1.509***
	(0.404)	(0.384)	(0.417)
Mean control group (BL)	3.105	1.379	3.895
No. children	498	498	498
R-squared	0.677	0.712	0.711
p-values associated with tests of equality			
(a) PI = LCT	0.014	0.026	0.057
(b) PI = PI x LCT	0.611	0.584	0.029
(c) LCT = PI x LCT	0.071	0.137	0.762
(d) F-test (all coeff's = 0)	0.037	0.069	0.067

Notes: Coefficients from main regression model are reported, with robust standard errors in parentheses. All specifications include controls for the household characteristics listed in Table 6 interacted with an indicator for endline, as well as the index child's age and gender and controls for the household's previous treatment group, all interacted with an indicator for endline. The outcome in column (1) is a measure from 1 to 5 about where the caregiver perceives the index child's height falls on the height visual shown in Figure 4 (1 is lowest, 5 is highest). The outcome in column (2) is a measure of the absolute value of the difference between the caregiver's perception of where the child falls and where the child actually falls (larger numbers indicate a bigger discrepancy). The outcome in column (3) is a measure of the caregiver's concern about the child's growth, ranging from a low of '1 - very concerned' to '5 - very satisfied'. ***p<0.01, **p<0.05, *p<0.1

Table 17
Program impact on index child food consumption in the last 7 days

Dependent variable	eggs	cereals	bread/pasta	meat/fish	fruit	vegetables	milk/dairy	legumes	oil/butter
Specification:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PI x Endline	0.239**	-0.051	0.056	0.073	0.223	0.546	0.345	-0.248	0.440*
	(0.116)	(0.143)	(0.245)	(0.138)	(0.22)	(0.414)	(0.286)	(0.35)	(0.247)
LCT x Endline	0.619***	-0.071	0.908***	0.273**	0.651***	0.385	0.067	-0.267	0.642***
	(0.187)	(0.106)	(0.234)	(0.134)	(0.227)	(0.4)	(0.297)	(0.357)	(0.248)
PI x LCT x Endline	0.739***	0.095	0.638***	0.288**	0.389*	0.208	0.239	-0.283	0.471**
	(0.171)	(0.159)	(0.227)	(0.133)	(0.219)	(0.392)	(0.291)	(0.335)	(0.223)
Endline	0.028	-0.006	-0.144	-0.053	-0.291	-0.085	0.184	2.080**	-0.135
	(0.504)	(0.417)	(0.629)	(0.319)	(0.59)	(1.03)	(0.718)	(0.877)	(0.664)
Mean control group (BL)	0.355	6.903	1.153	0.258	1.081	5.169	2.306	3.621	6.331
No. children	498	498	498	498	498	498	498	498	498
R-squared	0.658	0.599	0.663	0.621	0.638	0.571	0.823	0.672	0.692
p-values associated with tests of equality									
(a) PI = LCT	0.047	0.881	0.001	0.172	0.074	0.674	0.306	0.957	0.415
(b) PI = PI x LCT	0.004	0.370	0.014	0.144	0.486	0.367	0.695	0.916	0.890
(c) LCT = PI x LCT	0.597	0.239	0.250	0.917	0.284	0.624	0.543	0.964	0.454
(d) F-test (all coeff's = 0)	0.006	0.492	0.002	0.265	0.199	0.663	0.590	0.994	0.672

Notes: Coefficients from main regression model are reported, with robust standard errors in parentheses. Each column corresponds to a separate specification, with the indicated dependent variables (measured as number of days in the past week the index child ate each food). All specifications include controls for the household characteristics listed in Table 6 interacted with an indicator for endline, as well as the index child's age and gender and controls for the household's previous treatment group, all interacted with an indicator for endline. 'Cereals' refers to foods made with cereals: maize, wheat, barley, sorghum, teff, etc., and does not include bread, biscuits, or pasta. ***p<0.01, **p<0.05, *p<0.1

Table 18

Program impact on household food spending in the last 30 days

Dependent variable	eggs	cereals	bread/pasta	meat/fish	fruit/vegetables	milk/dairy	legumes	oil/butter	total food spending
Specification:	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
PI x Endline	1.322	-0.182	2.994	11.575	-0.383	-0.12	0.503	4.686	20.395
	(1.495)	(21.766)	(3.078)	(15.232)	(11.113)	(0.321)	(9.003)	(5.566)	(35.239)
LCT x Endline	15.333***	-4.91	14.205***	32.059**	21.914**	-0.354	-1.772	6.147	82.622**
	(2.06)	(18.601)	(3.554)	(15.432)	(10.876)	(0.42)	(8.594)	(5.414)	(32.385)
PI x LCT x Endline	8.884***	5.064	10.036***	33.293**	20.607*	2.192	10.857	5.323	96.258***
	(2.21)	(25.394)	(3.647)	(14.197)	(12.016)	(2.954)	(8.432)	(6.118)	(36.957)
Endline	4.024	53.132	-4.897	17.666	-21.671	3.611	-5.754	-12.819	33.293
	(5.171)	(60.471)	(9.489)	(35.082)	(28.029)	(3.544)	(22.18)	(17.088)	(93.654)
Mean control group (BL)	2.879	70.339	16.573	47.532	101.339	0.000	86.032	67.895	392.589
No. households	498	498	498	498	498	498	498	498	498
R-squared	0.654	0.716	0.680	0.690	0.674	0.506	0.736	0.803	0.780
p-values associated with tests of equality									
(a) PI = LCT	0.000	0.811	0.004	0.174	0.026	0.631	0.794	0.782	0.049
(b) PI = PI x LCT	0.000	0.850	0.082	0.109	0.072	0.464	0.233	0.918	0.043
(c) LCT = PI x LCT	0.013	0.691	0.339	0.927	0.905	0.394	0.109	0.890	0.688
(d) F-test (all coeff's = 0)	0.000	0.915	0.013	0.238	0.062	0.523	0.240	0.962	0.073

Notes: Coefficients from main regression model are reported, with robust standard errors in parentheses. All specifications include controls for the household characteristics listed in Table 6 interacted with an indicator for endline, as well as the index child's age and gender and controls for the household's previous treatment group, all interacted with an indicator for endline. Each column corresponds to a separate specification, with the indicated dependent variables corresponding to spending on each item in the last month (measured in birr). ***p<0.01, **p<0.05, *p<0.1

Table 19
Program impact on non-food household spending in the last 30 days

Dependent variable Specification:	health (1)	Soap /detergent (2)	school fees (3)	clothes/ shoes (4)	transportation (5)	total non-food (6)
PI x Endline	49.118	0.893	1.068	-9.235	3.565	45.409
	(61.462)	(2.192)	(7.886)	(31.85)	(9.161)	(70.918)
LCT x Endline	63.861	1.677	2.309	28.007	2.103	97.958
	(58.368)	(2.221)	(3.16)	(33.267)	(9.434)	(69.165)
PI x LCT x Endline	-20.270	-6.39	1.927	-0.253	-15.215	-40.201
	(60.635)	(4.95)	(2.306)	(29.259)	(17.789)	(72.441)
Endline	69.573	12.368	-4.771	-43.194	28.366	62.341
	(100.379)	(13.615)	(8.646)	(58.23)	(48.254)	(133.523)
Mean control group (BL)	137.887	20.710	3.355	83.242	17.581	262.774
No. households	498	498	498	498	498	498
R-squared	0.658	0.646	0.513	0.657	0.562	0.706
p-values associated with tests of equality						
(a) PI = LCT	0.660	0.752	0.868	0.255	0.878	0.274
(b) PI = PI x LCT	0.140	0.167	0.914	0.737	0.308	0.142
(c) LCT = PI x LCT	0.025	0.147	0.874	0.336	0.374	0.009
(d) F-test (all coeff's = 0)	0.079	0.343	0.973	0.498	0.594	0.033

Notes: Coefficients from main regression model are reported, with robust standard errors in parentheses. All specifications include controls for the household characteristics listed in Table 6 interacted with an indicator for endline, as well as the index child's age and gender and controls for the household's previous treatment group, all interacted with an indicator for endline. Each column corresponds to a separate specification, with the indicated dependent variables corresponding to spending on each item in the last month (measured in birr). ***p<0.01, **p<0.05, *p<0.1

Table 20
Stratified program impact on index child diet diversity

Dependent variable Specification:	BL HAZ < median (1)	BL HAZ > median (2)	BL WAZ < median (3)	BL WAZ > median (4)	Boys (5)	Girls (6)
PI x Endline	0.137	0.003	0.032	0.097	0.068	0.078
	(0.104)	(0.109)	(0.103)	(0.103)	(0.109)	(0.102)
LCT x Endline	0.313***	0.115	0.231**	0.201*	0.208**	0.226**
	(0.108)	(0.11)	(0.107)	(0.108)	(0.103)	(0.112)
PI x LCT x Endline	0.370***	0.269**	0.328***	0.341***	0.342***	0.320**
	(0.1)	(0.123)	(0.11)	(0.114)	(0.105)	(0.123)
Endline	-0.382	0.083	-0.231	-0.035	-0.201	0.006
	(0.267)	(0.293)	(0.272)	(0.301)	(0.266)	(0.298)
Mean control group (BL)	0.379	0.397	0.339	0.435	0.439	0.328
No. children	249	249	245	254	261	238
R-squared	0.697	0.640	0.681	0.649	0.675	0.657
p-values associated with tests of equality						
(a) PI = LCT	0.100	0.287	0.057	0.332	0.172	0.183
(b) PI = PI x LCT	0.023	0.023	0.006	0.027	0.007	0.041
(c) LCT = PI x LCT	0.588	0.188	0.369	0.223	0.163	0.469
(d) F-test (all coeff's = 0)	0.063	0.075	0.019	0.086	0.027	0.101

Notes: Coefficients from main regression model are reported, with robust standard errors in parentheses. All specifications include controls for the household characteristics listed in Table 6 interacted with an indicator for endline, as well as the index child's age and gender and controls for the household's previous treatment group, all interacted with an indicator for endline (the control for gender drops out in the last two specifications). The outcome in all columns is an indicator for whether the index child's food consumption met conditions for minimum dietary diversity, as defined in Table 7. The first two specifications stratify by whether the index child's baseline HAZ was above or below the median (-1.61). The second two specifications stratify by whether the index child's baseline WAZ was above or below the median (-1.05). The last two specifications stratify by the sex of the index child. ***p<0.01, **p<0.05, *p<0.1