Knowledge, Food Vouchers, and Child Nutrition: Evidence from a Field Experiment in Ethiopia[1]

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Abstract

Children in developing countries often consume diets of limited diversity, increasing their risk of chronic undernutrition. These monotonous diets are a consequence of many factors including poor maternal knowledge of child nutrition and limited resources. We implemented a clustered randomized control trial that randomly provides an intervention to improve maternal knowledge (Behavior Change Communication, BCC), the provision of food vouchers to address the income constraint, and a treatment group where both are provided. We find a reduction in chronic child undernutrition only when both BCC and vouchers are provided, even though BCC alone improves maothers' nutritional knowledge and child-feeding behaviors to some extent. Further, we find that BCC alone leads mothers to increase their self-employed farming labor supply to procure additional resources to support improved child-feeding practices. Food vouchers alone did not have any effect on mothers' nutritional knowledge or child-feeding behaviors. Our results suggest that, when both knowledge and income are intertwined challenges for improved child-feeding practices, addressing both constraints simultaneously may augment the positive impacts.

Keywords: infant and child nutrition, health information, behavior change communication, food vouchers, cluster randomized control trial, Ethiopia

JEL classification: I12, I26, J22, O12, O15

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1. Introduction

In developing countries, nutritional status is a critical component of health, especially for children under the age of two. Child undernutrition is linked to nearly half of all deaths in children under five and affects more than 150 million young children (World Bank, 2017). Chronic child undernutrition leads to poorer health, education, and labor outcomes in adulthood (Barrett, 2010; Black, et al., 2008; Hoddinott, et al., 2013).

The high prevalence of chronic child undernutrition could be explained by poor nutritional knowledge (Paul, et al., 2011), low income (Smith & Haddad, 2002), poor quality diets and food systems (Headey, Chiu, & Kadiyala, 2012), genetic predispositions (Nube, 2009), intrahousehold biases (Jayachandran & Pande, 2017), low status of women (Schroff, Griffiths, Adair, Suchindran, & Bentley, 2009), and the inefficacy of nutritional programs and strategies (World Bank, 2006). Previous research on interventions to address these challenges mostly focus on a single aspect of undernutrition such as micronutrient deficiencies (Muller, et al., 2003; Newton, Owusu-Agyei, & Kirkwood, 2007; Van der Merwe, et al., 2013), lack of knowledge (Prina & Royer, 2014), and lack of income (Manley, Gitter, & Slavchevska, 2013), which have often shown limited success.

Moreover, it is estimated that the summed impact of ten single-dimensional nutrition-specific interventions that could affect stunting, scaled up to nearly full coverage, would reduce stunting by only 20% (Bhutta, et al., 2013). This modest impact on stunting alleviation may be partly due to the single-dimensional approach most interventions take, despite the multifaceted and interdependent causes of undernutrition. This suggests that a multi-dimensional approach that tackles multiple causes simultaneously may be necessary to accelerate chronic child undernutrition reduction. Taking nutrition education and income as an example, nutrition education might have a limited impact if income levels are low to the extent that it hinders knowledge application. Transfer programs might have a limited impact if knowledge is a binding constraint. Both cases call for a multi-dimensional approach, providing both education and income simultaneously.

In this paper, we study the roles of knowledge and affordability in changing mothers' child-feeding practices, key barriers to improved child-feeding practices. We designed and implemented a community-based cluster randomized experiment in Ethiopia that provides nutrition education in the form of behavioral change communication (BCC) and food vouchers. Specifically, we randomly provided four-month-long BCC only (*BCC*), voucher only (*Voucher*), and both BCC and voucher (*BCC+Voucher*) interventions for mothers with one or more children between four and 20 months of age. This age range is important because stunting prevalence increases rapidly after the first six months as shown in Figure 1, which is when complementary feeding should start.[2] Thus, adopting healthy child-feeding practices during the transitional period from exclusive breastfeeding to complementary feeding is particularly crucial for preventing undernutrition (Black, et al., 2008; Jones, et al., 2003; Ruel, Alderman, & the Maternal and Child Nutrition Study Group, 2013).[3]

We find the greatest impact of *BCC+Voucher*, limited impact of *BCC*, and no impact of *Voucher* on child-feeding behaviors and child growth. *BCC* improves maternal nutritional

[2] Stunting prevalence is relatively low before six month from birth, but after six month from birth exclusive breastfeeding no longer meets the energy and nutrients needed for rapid child growth (Black, et al., 2013; Cunningham, Jelliffe, & Jelliffe, 1991; Dewey, Heinig, & Nommsen-Rivers, 1995; Beaudry, Dufour, & Marcoux, 1995).

[3] Appropriate complementary feeding means feeding children a diverse diet that meets the nutritional requirements. This entails feeding vitamin A-rich fruits and vegetables daily, in addition to a range of other fruits and vegetables. Meat, poultry, fish, or eggs also need to be consumed daily to ensure the intake of certain micronutrients critical for growth found only in animal source foods. In this regard, healthy food in this paper refers to these food groups (WHO, 2010).

knowledge and increase purchase of more diverse food and children's diet quality to some extent. Also, to procure additional food or income to support improved child-feeding practices, these mothers may increase their self-employed farming labor supply. However, these moderate improvements in child-feeding behaviors do not effectively lead to undernutrition reduction. As for the *Voucher* group, we find no effect on nutritional knowledge, child-feeding behaviors, and child growth. However, *BCC+Voucher* considerably augments the positive impacts on nutritional knowledge, child-feeding behaviors, as well as child growth.[4] *BCC+Voucher* ultimately leads to stunting reduction by 9.8 percentage points compared to the control group over the course of about six months. Moreover, it has distributional effects in that stunting is prevented among those in the lower tail of the child height-for-age distribution at baseline, amid the rapidly increasing child stunting rates in the control and other treatment villages. To examine whether knowledge from BCC is sustained in the community, we assess spillover effects on non-participating mothers of younger children.

Our results render important policy implications. For social protection or nutrition programs aiming to reduce child undernutrition, providing nutrition education and food voucher simultaneously could be most effective. Also, when implementing programs similar to *BCC+Voucher*, it may be best to target all infant and young children in the critical age range of 6 to 18 months, rather than targeting only the already undernourished children because *BCC+Voucher* is particularly effective in preventing stunting from occurring in this age range rather than reversing it.

[4] While the magnitude of the knowledge gain is similar between the *BCC* and the *BCC+Voucher* groups, the impact size of *BCC+Voucher* is nearly double that of *BCC* across a number of child diet quality measures that we examine, including child dietary diversity score, the proportion of children who meet the WHO's minimum dietary diversity, meal frequency, and acceptable diet standards.

This research contributes to several strands of literature. First, we contribute to the growing literature on the effectiveness of multifaceted “big push” programs on addressing the many challenges of poverty simultaneously. One example is the “graduation program” which brings sustainable and cost-effective results in reducing poverty by taking a multipronged approach, often combining skills training or education with income support and thereby releasing multiple constraints simultaneously (Bandiera, et al., 2017; Banerjee, et al., 2015). However, this literature has not been able to disentangle the individual effects of each intervention, which limits the ability to interpret whether and how the multifaceted approaches brought about synergistic effects. To our knowledge, this study is the first study to examine the combined effects of providing both education and vouchers on child-feeding behaviors and child nutrition. In addition, we are able to disentangle the individual effects of each intervention, which allows us to demonstrate that the combined interventions are complementary, rather than simply additive on stunting reduction.

Second, it contributes to the empirical literature on the effects of nutrition education or BCC for caregivers on caregivers' nutritional knowledge, child-feeding behaviors, and child growth. Recent experimental studies on BCC conducted in Bangladesh and Burkina Faso have provided causal evidence on the effectiveness of nutrition education programs on improving nutritional knowledge among caregivers and neighbors, feeding practices, and nutritional outcomes, but do not report results on stunting reduction which is the ultimate goal of the program (Fitzsimons, Malde, Mesnard, & Vera-Hernandez, 2016; Hoddinott J. , Ahmed, Karachiwalla, & Roy, 2018; Hoddinott J. , Ahmed, Ahmed, & Roy, 2017; Olney, Pedehombga, Ruel, & Dillon, 2015; Zongrone, et al., 2018).[5]

Third, this research adds to the literature on the role of vouchers in improving child nutrition in developing countries. In the case of cash transfers, a meta-analysis examining 21 papers on 17 programs find that cash transfers have a positive but small and not statistically significant impact on child height (Manley, Gitter, & Slavchevska, 2013). Other studies find that cash transfers and/or food vouchers improve dietary diversity, but the results are mostly at the household level (Aker et al. 2016; Haushofer and Shapiro 2016; Hoddinott et al. 2015). Our study revisits this question with a focus on infant and young children's diets and growth, with a transfer amount comparable to that of a major government transfer program in Ethiopia. The remainder of this paper is organized as follows: Section 2 lays out a simple conceptual framework; Section 3 presents the study design and the interventions; Section 4 describes the data and sample characteristics; Section 5 sets out the methods; Section 6 presents the results; Section 7 shows heterogeneity analysis and robustness checks; and Section 8 presents the cost-effectiveness analysis. We discuss the results and conclude in Section 9.

2. Conceptual Framework

In this section, we present a conceptual framework that motivates our experimental design and guides empirical analysis. This framework explains how BCC and voucher interventions affect

[5] Moreover, existing studies provide evidence on interventions that are long-term, mostly two years, which are often costly and difficult to implement at large scale. Our study adds to the literature, as well as confers important policy implications, by demonstrating the effectiveness of a relatively short-term and cost-effective BCC program that leads to stunting reduction.

household decisions. Building on the literature using a child health production function (Del Boca et al. 2014; Fitzsimons et al. 2016; Gronau 1986; Rosenzweig and Schultze 1983), we conceptualize that households are concerned about adult consumption (*X*) and their children's health (*H*) which is a function of nutritional input (*C*) and knowledge (*K*). For simplicity, we assume that each household has one adult and one child. The household maximizes the following welfare function by choosing *C* and *X* simultaneously:

$$\max_{\mathrm{X,C}} U(A,X) = A(X) + H(C,K)$$

$$s.t. \quad X + pC \leq Y$$

where *U(.,.)* captures the utility from adult consumption and child health. *p* is the price of child nutrition input relative to adult consumption, and *Y* is income. The function *A(.)* represents the adult consumption utility function and *H(.,.)* represents the child health production function. We assume that *A(.)* is increasing in *X* and concave, and H(.,.) is increasing in *C* and *K*.

We assume two different types of child health production function and compare the expected results. First, we present a general case where the *C* and *K* are imperfect complements, represented by a Cobb-Douglas child health production function. Alternatively, we illustrate a case where the child health inputs are very interdependent with each other—i.e., the usage of knowledge is constrained by nutritional input and vice versa. This case is characterized by a (near) perfect complement relationship expressed by a Leontief child health production function.

Case 1: General Child Health Production Function

Assume that the adult consumption utility and the child health production function are Cobb-Douglas: $A(X) = \gamma lnX$ and $H(C,K) = \alpha lnC + \beta ln\mathrm{K}$ where $\alpha, \beta, \gamma > 0$ and $\alpha + \beta < 1$. The optimization problem is:

$$\max_{X,C} \gamma lnX + \alpha lnC + \beta lnK$$

$$s.t. \quad X + pc \leq Y$$

where *K*, *p*, and *Y* are given. To study the effect of the intervention, we differentiate the first order condition with respect to *Y* and *K*, and find that $\partial H/\partial Y > 0$ and $\partial H/\partial K > 0$ (see Appendix B for the proof). With positive marginal child health returns to income and knowledge, it follows that $H^0 < H^V \lesseqgtr H^B < H^{BV}$, where H^0, H^V, H^B, H^{BV} denote child health status given no change (control), given increase in income (*Voucher*), given increase in knowledge (*BCC*), and given increase in both (*BCC+Voucher*), respectively.

Case 2: (Near) Perfect Complements Child Health Production Function

To illustrate a simplified case in which the marginal returns to an input is constrained by the other input, we assume a perfect complement relationship between nutritional input and knowledge. This is represented by $H(C,K) = \min\{\alpha C, \beta K\}$, with $\alpha, \beta > 0$. We can therefore rewrite the optimization problem as:

$$\max_{X,C} A(X) + \min\{\alpha C, \beta K\}$$

$$s.t. \quad X + pC \leq Y$$

where *K*, *p*, and *Y* are given. The optimal bundle for perfect complements satisfies $\alpha C = \beta K$, i.e., optimal bundles are located at the kinks of the indifference curves. As the kinked child health production function cannot be differentiated, we graphically show that $\partial H/\partial Y = 0$, $\partial H/\partial K \geq 0$, and $\partial H/\partial Y \partial K > 0$ (see Appendix B for the proof). In other words, marginal returns of income to child health is zero due to the lack of knowledge, and marginal returns of knowledge to child health can be positive through intrahousehold budget or food reallocation but is still constrained by income. Given increase in both income and knowledge, households are able to afford the increase in knowledge, leading to further increase in child health. Therefore, in this case, we find that $H^0 = H^V \leq H^B < H^{BV}$.

The above two cases of child health production functions that assume a general relationship versus a near perfect complement relationship between *C* and *K* allow us to establish the following proposition:

Proposition 1. If C and K are imperfect complements, then $H^0 < H^V \lesseqgtr H^B < H^{BV}$. However, if C and K are (near) perfect complements, then $H^0 = H^V \leq H^B < H^{BV}$.

The intuition is that if nutritional input and mothers' knowledge respectively improve child health in a way that does not mutually constrain their marginal benefit, then both *BCC* and *Voucher* treatments separately will improve child nutritional outcomes to some extent, with the improvement in the *BCC+Voucher* group being the sum of the two separate effects. However, if nutritional input and mothers' knowledge mutually constrain each other's marginal child health improvements, then the *Voucher* treatment will not improve child nutritional outcomes as it is constrained by knowledge, while *BCC* may improve child health to some extent through household budget or food reallocation. Child health improvements will be greatest for the *BCC+Voucher* group, with positive complementary effects of combining BCC and vouchers. Whether the first or the second case holds is ultimately an empirical issue, which we estimate using the study design below.

3. Study Design and the Interventions

3.1. Study Context

Ethiopia is one of the least developed countries in the world with GDP per capita in 2015 of US$707 (World Bank, 2017), and the second most populous country in sub-Saharan Africa. Ethiopia is an appropriate setting for this study with significant child nutrition challenges. The prevalence of stunting in Ethiopia, an indicator for chronic undernutrition, was 38% among children under five (Ethiopia DHS, 2016). The prevalence of stunting rapidly increases after six months of age, largely due to poor infant and young child-feeding practices in Ethiopia. In 2016, at the age of six months, 16% of children are stunted in Ethiopia but the corresponding number increases to 47% by 24 months (Ethiopia DHS, 2016). Low dietary diversity is particularly striking among young children in Ethiopia, with only 7% of children aged 6-23 months meeting the minimum acceptable dietary standards (Ethiopia DHS, 2016).

Our study area is Ejere district (*woreda*) located in the Oromia region of central Ethiopia, approximately 50 km west of the capital, Addis Ababa. Ejere is primarily a rural district which is further subdivided into three urban and 27 rural wards (*kebeles*). Ejere has a population of around 112,000 spread over these 30 wards, who are predominantly engaged in mixed crop-livestock farming at a small scale. Most farmers engage in traditional practices of rain-fed subsistence agriculture.

3.2. Experimental Design

We implement a cluster randomized control trial that randomly provided nutrition BCC and food vouchers.[6] The study area is three urban and three randomly selected rural wards out of 30 wards in Ejere (Figure 2). A total of 79 villages (*garees*) from these six wards in Ejere entered a lottery, and were randomly selected into one of four arms: BCC only (*BCC*), vouchers only (*Voucher*), BCC and vouchers (*BCC+Voucher*), and the control group. Randomization was stratified by wards. The study sample is mothers with at least one child aged between 4 and 20 months.[7] There are 101 (15), 96 (14), 154 (13), and 290 (37) mother and child pairs (villages) randomly assigned to the *BCC*, *Voucher*, *BCC+Voucher*, and control study groups, respectively.[8] We also include pregnant women and women with children under 4 months in the same villages to study IYCF knowledge

[6] The interventions were designed by the study team through a series of focus group discussions and pilot-testing as shown in study timeline (Figure 4). We find that mothers in study area often believe that babies under 12 months should not be fed animal source foods. Also, it is common to give infants as old as nine months only thin gruel, with the misbelief that they are not able to digest solid or semi-solid food. The widely available and inexpensive healthy food items in the area, such as mangos rich in vitamin A, are not well recognized.

[7] As discussed in Section 1, we selected the age range between 4 and 20 months as the treatment eligibility criteria in order to target the age range that is most susceptible to undernutrition due to malpractices in child-feeding. In particular, we seek to address chronic undernutrition caused by suboptimal practices in complementary feeding, which starts at 6 months of age. We do not include children under 4 months because the BCC intervention does not address breastfeeding practices.

[8] To address the issue of small number of clusters, we use the wild-cluster bootstrap (Cameron, Gelbach, & Miller, 2008) and randomization inference methods to obtain valid inference (Fisher, 1935; Rosenbaum, 2002). We discuss it further in Section 5.

spillovers (spillover group). The corresponding numbers for the spillover group are 86, 54, 97, and 107 mother and child pairs, respectively. Figure 4 summarizes the study design.

3.3. Interventions

BCC. [9] The BCC treatment was an interactive information intervention on infant and young child feeding (IYCF) complemented by various participatory learning methods including weekly sharing of mothers' experiences applying new IYCF activities, videos and visual images, role-plays, and cooking sessions. [10] The BCC education is designed for a 16-week period to cover all of the key topics in IYCF while maximizing cost-effectiveness. [11] An overview of the BCC curriculum is provided in Appendix C. The focus of the BCC sessions and supporting activities was on the need to increase dietary diversity of children aged 6-23 months, with an emphasis on animal source foods and vitamin A-rich fruits and vegetables, appropriate feeding amounts and frequency, and feeding and caregiving practices. Each session ended with an action plan the mothers agreed upon, and the proceeding session reviewed and discussed past week's action plans. In addition, the BCC participants also received a small handbook containing a summary of IYCF contents and weekly action plans based on contents learned each week, and a self-check diary.

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[9] BCC is the strategic use of communication to promote positive health outcomes, based on proven theories and models of behavior change. BCC employs a systematic process beginning with formative research and behavior analysis, followed by communication planning, implementation, and monitoring and evaluation. Audiences are carefully segmented, messages and materials are pre-tested, and mass media (which include radio, television, billboards, print material, internet), interpersonal channels (such as client-provider interaction, group presentations) and community mobilization are used to achieve defined behavioral objectives (MEASURE Evaluation, 2018).

[10] Our BCC program curriculum is developed based on the Alive & Thrive's BCC program implemented in Ethiopia. Alive & Thrive is an initiative to save lives, prevent illness, and ensure healthy growth and development through the promotion and support of optimal maternal nutrition, breastfeeding, and complementary feeding practices. Alive & Thrive has worked in Ethiopia since late 2009 to address widespread and limited recognition of the long-term consequences of stunting and find ways to reach mothers (Alive & Thrive, 2018).

[11] Most existing studies evaluate 2-year-long BCC interventions which are difficult to implement at scale (Hoddinott J. , Ahmed, Ahmed, & Roy, 2017; Olney, Pedehombga, Ruel, & Dillon, 2015).

The BCC facilitators consisted of local female community workers who had been working in the community as social workers for at least six months up to five years. All mothers who have a child from 4 to 20 months living in the same village formed a group of seven to sixteen mothers to receive the BCC education. Each group had two designated facilitators—one leader and one helper. The lead facilitator taught the sessions and led discussions and role-plays, while the other facilitator helped by encouraging discussion and assisting illiterate mothers. The sessions were conducted at the ward office or health posts. Throughout the study, two supervisors randomly visited the BCC sessions for quality control. The supervisors also made home visits to mothers who missed more than two consecutive sessions to encourage attendance. The BCC facilitators, supervisors, and the study team had weekly group meetings to discuss progress and challenges.

Food vouchers. The voucher treatment provided food vouchers of 200 ETB (approximately 10 USD) per month for four months to the household, which could be used at nearby markets.[12] Vouchers were given in denominations of 5, 10, and 20 ETB to facilitate small transactions, and were required to be redeemed within the expiration date (four weeks) noted in the voucher (Panel A of Figure A1). Food vouchers were redeemable for any kind of food items sold at the market including cereals, roots and tubers, fruits, vegetables, legumes, meat and fish, milk products, eggs, oil, sugar, and spices. Food vouchers were distributed every four weeks at the nearest market or at the participant's household if not picked up from the market. At the first

[12] This amount is similar to the cash or food transfers amount of Ethiopia's Productive Safety Net Program which was set to be about 8.5 USD at the time of the program design (MOA, 2014). We provide food vouchers instead of cash or food given evidence that food vouchers have been shown to be most effective in improving dietary diversity (Hidrobo, Hoddinott, Peterman, Margolies, & Moreira, 2014).

disbursement, voucher recipients were provided detailed instructions on how to use the vouchers.

To prevent fraudulent transactions or transfers, study participants were required to present household photo IDs, provided by the study team, to redeem the vouchers, which were cross-checked by the merchants with the unique household ID number and names on the vouchers (Panel B of Figure A1).[13] On all market days of the study period, our voucher staff were stationed at the market to facilitate transactions and recorded voucher-based transactions.

4. Data

4.1. Data Sources

The primary data sources are (1) census data including household demographic and socioeconomic information, (2) the baseline and follow-up surveys, and (3) administrative data collected during the intervention including BCC attendance rates and voucher usage records. The timeline of the data collection and interventions is summarized in Figure 2.

AFF conducted a census of all households in 22 wards of Ejere in May-September 2016, covering approximately 22,000 households.[14] The census collected a variety of demographic, socioeconomic, and health variables such as the age of mother and children, marital status, education and employment, household asset, and birth history of the mother. Using the census data, we randomly selected three rural wards and selected all three urban wards. From these

[13] The vouchers and the IDs were stamped by the official AFF mark in blue in order to avoid duplicates.
[14] Out of 30 wards in Ejere, 8 wards in the southern part of the district were excluded from the census due to security reasons. There were strong anti-government sentiments in this region which spread to hostility toward NGOs and surveyors.

wards, we randomly selected 79 villages to be included in this study.[15] These villages had a total of 641 eligible mother and child pairs, all of which were included in the study for the treatment and control groups, and 344 mother and child pairs for the spillover.

The baseline survey was conducted in April-August 2017 before the intervention program began. The follow-up survey was conducted upon program completion in December-March 2018, about 6 months after the baseline survey. Both the baseline and the follow-up questionnaires include detailed information on IYCF knowledge and practices, child food consumption, household food and non-food expenditures, health, gender, social networks, anthropometry, demographics, and socioeconomic information. The follow-up survey also has a section on the mothers' experience with the program.

During the baseline and follow-up surveys, we asked study participants to list up to ten closest friends (including relatives) within the ward. Using this social network data, we construct BCC peer variables including whether the mother has any BCC-participating friend and the number of BCC-participating friends by cross-referencing the networks with BCC participants and vice versa.[16] At baseline, 55% of BCC treatment mothers and 36% of spillover group mothers had at least one BCC-participating friend, defined either by own network or the other person's network at baseline.

[15] The six wards consisted of a total of 105 villages of which 79 villages were considered in this study as a part of a nested study design and the rest are considered in a separate study.

[16] The social network was created from the network module in the baseline and follow-up surveys asking the respondent to list the top 10 closest friends living in the same ward. Matching was done initially by matching phone numbers, then by matching the friends' names with survey respondent and spouse names using the similarity score generated by the 'matchit' command in Stata. Name matches with similarity score above 0.6, out of a range from 0 to 1, were manually compared across name, spouse name, sex, ward, and phone number to confirm the match. Manual confirmation was necessary due to inconsistent spelling of Amharic and Oromo names.

In addition, our research team collected administrative data on BCC attendance and voucher usage during the intervention. On voucher usage, the voucher staff collected information on the type of food item, the quantity bought, and the amount spent using the vouchers.[17] These data show that most of the voucher participants utilized the vouchers to buy food at least once (94%), and 88% of face value of the voucher had been redeemed (on average 175 out of 200 ETB). Administrative data show that mothers attended the BCC sessions regularly (74% attendance rate).

4.2. Outcome Variables

The primary outcomes for this study are mother's IYCF knowledge scores and child dietary diversity score (CDDS). We also constructed other measures of children's diet quality, household food and non-food consumption and expenditures, measures of household diet quality, and anthropometric measures of child development.[18]

The mother's IYCF knowledge score is the percentage of questions answered correctly out of 34 questions. The CDDS, an indicator of dietary quality, sums the number of distinct food groups consumed by the child in the past 24 hours.[19] Other child diet quality and quantity

[17] When voucher-holders visited the market, the voucher staff followed the voucher-holders to record each transaction they made.
[18] The outcome variables considered in this study are pre-specified in the pre-analysis plan at AEA RCT Registry (Han, Hoddinott, Kim, & Park, 2013).
[19] This measure is based on seven different food groups: cereals, roots, and tubers; legumes, nuts, and seeds; dairy products; meat/poultry and fish; eggs; vitamin A-rich fruits and vegetables; and other fruits and vegetables (WHO, 2010). Dietary diversity is a useful indicator for diet quality, as it is shown to be positively associated with mean micronutrient density adequacy (Working Group on Infant and Young Child Feeding Indicators, 2006).

measures including minimum acceptable diet, minimum dietary diversity, and minimum meal frequency standards are based on WHO guidelines (WHO, 2010).

The minimum acceptable diet indicator is created assessing two different IYCF components compiled into one index, adjusted for child's age: minimum dietary diversity[20] and minimum meal frequency.[21] Minimum acceptable diet differs from CDDS in that it accounts for feeding frequency in addition to diversity and focuses on improvements in the lower tail of the distribution (WHO, 2010).

To gauge how knowledge changes, we also measured mothers' perception of relative child growth by asking how the child fares compared to other children of the same age in terms of diet quality on a five-tiered scale ranging from very well to very poor. Additionally, we constructed a variable for timely introduction of complementary food using a total standardized score aggregating indicator variables for whether the child started eating a certain food after six months but before 12 months of age across eight different complementary food items. This outcome measures how well mothers are doing in terms of introducing various complementary food to their children at appropriate ages—not too early as to incur digestive problems but not too late so that children are not undernourished.[22]

[20] Minimum dietary diversity is proportion of children who receive food from 4 or more food group, and minimum meal frequency is the proportion of children who consumed minimum number of meals appropriate for the age (WHO, 2010). Minimum dietary diversity is a proxy for adequate micronutrient density of foods. The cut-off of four food groups is associated with better-quality diets for both breastfed and non-breastfed children. The four food groups should come from a list of seven food groups: grains, roots, and tubers; legumes and nuts; dairy products (milk yogurt, cheese); flesh foods (meat, fish, poultry, and liver/organ meat); eggs; vitamin A-rich fruits and vegetables; and other fruits and vegetables.

[21] Minimum meal frequency, a proxy for a child's energy requirements, examines the number of times children received foods other than breastmilk. The minimum number is specific to the age and breastfeeding status of the child (WHO, 2010).

[22] The complementary food items asked are water or other non-breastmilk liquids, solid or semi-solid food, meat, eggs, legumes, green vegetables, fruits, and snacks.

In order to examine household-level expenditure responses to nutritional knowledge and food vouchers, we calculate household food expenditure by summing the value of food items purchased in the past seven days by food group or in total. Food items include cereals, roots and tubers, nuts and legumes, fruits and vegetables, meat and poultry, eggs, milk and milk products, and spices and condiments. Household non-food expenditure is calculated from the value of durable items purchased in the last six months and non-durable items purchased in the last month. All values are converted to weekly per capita values. Non-food items include clothing, household items, medical costs, educational costs, energy costs, repair costs, and wedding/funeral costs. All values are converted to weekly per capita values.

To assess how household-level diet quality changes as a result of knowledge and vouchers, we also construct a food consumption score (FCS) which measures household diet quality in terms of both energy and diversity (Weismann, Bassett, & Hoddinott, 2009).[23] FCS less than or equal to 35 is considered having poor to borderline consumption (WFP, 2008).

Further, to see whether BCC and/or vouchers influence labor supply decisions, we construct labor supply outcomes. In particular, we examine whether the mother engaged in and the number of hours worked on self-employed farming as own production is a major food source.

Lastly, we examine the treatment effect on children's physical growth using child anthropometry which was measured three times during each survey to minimize error. Child growth outcomes include height-for-age Z scores (HAZ) and stunting. These were constructed using a mean of the three measurements for height. HAZ is a standardized Z score relative to the

[23] The FCS is calculated by summing the number of days that the household consumed each of the eight food groups (staples, pulses, vegetables, fruit, meat and fish, milk and dairy, sugar and honey, oils and fats), multiplying the summed number of days by the food group's weighted frequencies, and summing these weighted scores across food groups.

WHO reference population. Stunting is a dummy variable equal to 1 if a child's HAZ is 2 standard deviations (SD) below the WHO reference population.

4.3. Sample Characteristics and Randomization Balance

Table 1 presents the summary statistics for the whole sample (Column 1), the control group (Column 2), and the difference between each treatment groups and the control group (Columns 3 to 5) and between treatment groups (Columns 8-10). Panels A, B, and C present mother, child, and household characteristics at baseline, respectively. At baseline, mothers in our sample are, on average, 28 years old, 77% are Oromos, 84% are Orthodox Christians, 77% are married, 56% have work, 50% are able to read, 49% are able to write, have about 4 years of schooling, and the mean mother IYCF knowledge score is 21.5 out of 32 (67%). Mean age of the eligible child is approximately 12 months, the mean CDDS is 2.4, only 13% met the minimum acceptable diet at baseline, and the mean HAZ is -1.1 with a 27% stunting prevalence. At the household level, 14% are female-headed, average household size is 4.5, have approximately 2 children, and 45% are from rural areas. Average total weekly food and non-food expenditure per capita are approximately 132 ETB and 43 ETB, respectively, with FCS of 43.

Columns 3 to 10 confirm that the randomization was successful, with the sample well balanced across intervention and control clusters at baseline.[24] Across 144 (24 x 6) difference-in-

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[24] We test for baseline differences between treatment and control groups (Columns 3-5) using the following specification: $y_{ij0} = \beta_0 + \beta_1\, BCC_{ij} + \beta_2\, Voucher_{ij} + \beta_3\, BCC\&Voucher_{ij} + \varepsilon_{ij}$. y_{ij0} is the outcome of interest for household *i* from village *j* at baseline. BCC_{ij}, $Voucher_{ij}$, and $BCC\&Voucher_{ij}$ are treatment indicators equal to one for households living in treated villages. Thus, β_1, β_2, and β_3 represent the differences in means at baseline between the treatment and the control groups. Standard errors are clustered at the village level, the unit of randomization. Similarly, to test for baseline differences between treatment groups (Columns 8-10), we separately estimate: $y_{ij0} = \beta_0 + \beta_1\, BCC_{ij} + \varepsilon_{ij}$ for *BCC* vs. *Voucher* and *BCC* vs.

means tests, only two differences are statistically significant at the 5% level, suggesting that the baseline characteristics are balanced overall. With 144 tests being considered, the probability of rejecting a true null hypothesis for at least one outcome is nearly 100%. We also test for joint equality of all treatments' mean differences with the control group using an F-test (Column 6) and find that none are rejected at the 5% level. Lastly, we conduct a test for joint orthogonality reported in the last row of Table 1 and find that these baseline characteristics are jointly orthogonal to each treatment at the 5% level.[25] As a robustness check, we also control for these baseline covariates in the analysis.

As shown in Panel D, eligible mothers' attrition rate at the follow-up survey is 8.4%. Table 1 shows no significant difference in attrition rates across intervention groups. The attrition rate of follow-up child anthropometry is 16.5%. It is significantly different between the *BCC* and the *Voucher* groups (Column 8), but this comparison is not the main focus of our analysis on anthropometry.

5. Methods

Our estimation strategy relies on the randomized design of the program, which provides a clean source of identification. Our basic treatment effects specification estimates the following equation:

BCC+Voucher comparisons; or $y_{ij0} = \beta_0 + \beta_1 Voucher_{ij} + \varepsilon_{ij}$ for *Voucher* vs. *BCC+Voucher* comparisons, restricting the sample to the treatment groups being considered.

[25] We test for joint orthogonality by estimating the following specification: $T_{ij} = \beta_0 + \beta_1 y_{ij0}^1 + \beta_2 y_{ij0}^2 + \ldots + \beta_{24} y_{ij0}^{24} + \varepsilon_{ij}$, where T_{ij} represents the respective treatment group of interest—*BCC*, *Voucher*, or *BCC+Voucher*—and y_{ij0}^1, y_{ij0}^2, ..., y_{ij0}^{24} are baseline characteristics considered in Table 1. We estimate this equation restricting the sample to the treatment group of interest and the control group. We then test the joint hypothesis $\beta_1 = \beta_2 = \cdots = \beta_{24} = 0$ with an F-test. P-values from this test are reported in the last row of Table 1.

$$y_{ij1} = \beta_0 + \beta_1 BCC_{ij} + \beta_2 Voucher_{ij} + \beta_3 BCC\&Voucher_{ij} + \beta_4 y_{ij0} + \beta_5 X_{ij} + \varepsilon_{ij}$$

where y_{ij1} is the outcome of interest for household *i* from village *j* at follow-up including mother's nutritional knowledge score, household food and non-food expenditures, nutrition indicators including CDDS, minimum acceptable diet, FCS, and child HAZ score. BCC_{ij}, $\mathrm{Voucher_{ij}}$, and $BCC\&Voucher_{ij}$ are dummy variables equal to one if the respondent was living in the *BCC*, *Voucher*, or the *BCC + Voucher* treatment villages, respectively, at baseline and zero otherwise. Hence, β_1, β_2, and β_3 represent the intent-to-treat estimators. y_{ij0} is the outcome of interest at baseline. X_{ij} is a control vector of household *i*'s characteristics including demographic variables (mother's age, eligible child's age, marital status, household size, number of children, ethnicity, religion) and socioeconomic status (mother's literacy, years of schooling, employment status, and household assets). ε_{ij} is an error term and errors are clustered at the village level. We present results using the specification that includes the control vector, but the outcomes are nearly identical when different specifications are used.[26]

To address the issue of small number of clusters, we use the wild-cluster bootstrap (Cameron, Gelbach, & Miller, 2008) and randomization inference methods to obtain valid inference (Fisher, 1935; Rosenbaum, 2002).[27] In each results table, we report clustered standard

[26] The estimation and selection of the baseline controls strictly follows Section 4 of the pre-analysis plan at AEA RCT Registry (Han, Hoddinott, Kim, & Park, 2013).

[27] We use the Stata command 'boottest' and 'ritest' to obtain the wild-cluster bootstrap and randomization inference p-values, respectively. In both procedures, we use 999 replications and the seed number 20000.

errors as well as the p-values computed using both the wild-bootstrap cluster procedure and randomization inference.

In order to account for multiple hypotheses testing (Christensen & Miguel, 2018), we group child diet quality outcome measures into one domain and take an average standardized treatment effect (Finkelstein, et al., 2012; Kling, Liebman, & Katz, 2007).[28] We compute the average standardized treatment effect by stacking the data for the individual outcomes within the domain and estimating a single regression equation while clustering standard errors both at the village level and at the individual level.

Next, we use the network data to estimate whether the treatment also influenced the outcomes of peers of the participants. The extent of such spillover effects or information spillovers can be estimated with the following specification:

$$y_{ij1} = \alpha_0 + \alpha_1 Peer_{ij} + \alpha_2 y_{ij0} + \alpha_3 X_i + \varepsilon_{ij}$$

where y_{ij1} and y_{ij0} are nutritional knowledge scores for household i from village j at follow-up and baseline, respectively. $Peer_{ij}$ is the number of BCC-participating friends the spillover group respondent has. We use three different definitions of the $Peer_{ij}$ variable: 1) the number of BCC participants who listed the spillover group mother as a friend, and the spillover group mother also listed the BCC participants as a friend; 2) the number of BCC participants who listed the

[28] We summarize multiple findings across related outcomes within a domain *J* by the average standardized treatment effect: $\sum_{j \in J} \frac{1}{J} \frac{\rho_{1j}}{\sigma_j}$ where σ_j is the standard deviation of y_j in the control group and ρ_{1j} is the coefficient of interest for outcome *j*. In order to account for covariance in the estimates of $\frac{\rho_{1j}}{\sigma_j}$, we estimate pooled OLS for all outcomes $j \in J$.

spillover group mother as a friend; and 3) the number of BCC participants the spillover group mother listed as friends.

6. Results

6.1. BCC Attendance and IYCF Knowledge

We first show whether the BCC treatment successfully improved knowledge on IYCF. Table 2 presents the impacts on BCC attendance and standardized mothers' IYCF knowledge. Using the BCC administrative data, Column 1 of Table 2 compares the overall BCC attendance rates across treatment. Note that attendance rate for the *Voucher* group and the control group are zero as expected. On average, the *BCC* and the *BCC+Voucher* group have 73% and 75% attendance rates, respectively, and they are not statistically different from each other.

In Column 2, we find that attendance in the BCC sessions led to significant knowledge gains: 0.48 and 0.42 SD for the *BCC* and the *BCC+Voucher* groups, respectively.[29] This is comparable to other studies with longer intervention periods lasting up to two years (Hoddinott J. , Ahmed, Ahmed, & Roy, 2017; Olney, Pedehombga, Ruel, & Dillon, 2015). Hence, we show that a similar or greater impact on mothers' knowledge can be attained with a relatively short treatment length at least in the short run. However, receipt of the voucher alone has no such effect, as expected. We cannot reject the null that the magnitudes of the impact of *BCC* and

[29] Mothers in the *BCC* and the *BCC+Voucher* groups answered about 2 more out of 34 questions correctly compared to the control group.

BCC+Voucher differs, suggesting that receiving vouchers in addition to the BCC intervention does not further increase knowledge gains.[30]

6.2. Voucher Redemption

We also show results on voucher redemption using the voucher administrative data (Table 3).[31] Column 1 shows that the *Voucher* and the *BCC+Voucher* groups spent, on average, 176 and 173 ETB worth of food vouchers per month, respectively, redeeming about 88% of the disbursed voucher amount. The amount redeemed per month is not statistically different between the *Voucher* and the *BCC+Voucher* groups.

Columns 2-11 show that the food vouchers are spent on most food groups in similar amounts between *Voucher* and *BCC+Voucher*. While large amounts are spent on starchy staples and oils and fats, households allocate a third of their voucher spending on non-staple food including dairy products, eggs, fruits and vegetables, and nuts and legumes. This is consistent with the literature on income elasticity for nutrients suggesting that increased income leads to a preference for higher quality foods and more diversified non-staple diets (Bilal, et al., 2013; Skoufias, di Maro, Gonzales-Cossio, & Ramirez, 2011). Meat is not usually bought with vouchers, as they are usually not sold in the market but obtained from their own or neighbor's livestock. Voucher redemption patterns over time are presented in Figures A2 and A3. They illustrate that

[30] Attendance rates and knowledge scores by IYCF topic are presented in Table A1.

[31] The voucher redemption amount of the control group are zero as they did not receive vouchers, and the BCC group is not included in this analysis.

voucher expenditures are front-loaded in any given month except for the first month, and that voucher redemption by food group change little over time.

6.3. Child Diet Quality

Having established that the BCC intervention resulted in knowledge gain among mothers and that voucher recipients spent the food vouchers, we now look at effects on mothers' child-feeding behaviors, reflected in the quality of children's diets. It is worth noting that we collected data on child diet quality just after the completion of the voucher intervention, and therefore, it does not capture direct impacts of the voucher. Also, the results on children's dietary intake are based on mothers' reports which is subject to self-reporting bias caused by social desirability or recall errors.

We find that CDDS increased by 0.33 and 0.59 food group in the *BCC* and *BCC+Voucher* group, respectively (Column 1 of Table 4). However, we do not find impacts on child diet quality in the *Voucher* group. The results on minimum acceptable diet (Column 2) is similar to that of CDDS.[32] The magnitude of the increase for the *BCC+Voucher* group is double that of the *BCC* group, by 9 and 15 percentage points, respectively, and the difference between the two groups is statistically significant at the 10% level. The results on CDDS and minimum acceptable diet suggest that mothers are able to feed more diverse food to their children when provided appropriate education alone to some extent, which could be even larger when they have

[32] Results on minimum dietary diversity and minimum feeding frequency, which are the components of minimum acceptable diet, are presented in Table A2.

additional financial support. In addition, while our interventions focused on improving children's diets, we find some positive impact of BCC on household diet quality also (Table A4).[33]

Unlike the results on the previous two measures, on timely introduction of complementary food (Column 3), we find that the coefficient on *BCC* has nearly the same size as the coefficient on *BCC+Voucher*. A possible explanation is that as there is relatively little or no cost to adjusting the timing of introducing various foods, compared to increasing food quantity or diversity, both *BCC* and *BCC+Voucher* households similarly improved their child-feeding behavior in this regard.

In addition, we study impacts on perceived relative child dietary quality (Column 4). Results are interesting in that mothers in the *Voucher* group perceive that their children have better diet quality when, in fact, they do not. This suggests that mothers' perception of their own feeding practices could be dependent on their nutritional knowledge. Absent knowledge of appropriate feeding practices, mothers may have misconceptions about what constitutes a good diet for their children, and therefore misperceive that their children's diet quality is better than others.

Lastly, we show a standardized treatment effect of outcomes from Columns 1 to 4 to address the issue of multiple hypothesis testing as described in Section 5. Collectively, we find improvements in child diet quality for the *BCC* and *BCC+Voucher* groups by 0.05 SD and 0.08 SD, respectively, and the difference between two groups is statistically significant at the 10% level.

[33] Diet quality at the household level, as measured by FCS, improves among the *BCC* and the *BCC+Voucher* groups but not the *Voucher* group (Column 1). It is possible that some nutritional information with general application was applied to the overall household diet—e.g., the emphasis on dietary diversity and essential micronutrients. This is also supported by results on household food consumption by food group (Columns 2-11), which shows that improvements in household diet quality is driven by the consumption of food groups highlighted in the BCC sessions, notably animal source foods and vitamin A-rich fruits and vegetables.

The limited existing literature on the effects of BCC or nutrition education on child-feeding practices find smaller effect sizes on limited types of diet quality measures (Fitzsimons, Malde, Mesnard, & Vera-Hernandez, 2016; Olney, Pedehombga, Ruel, & Dillon, 2015; Reinbott, et al., 2016).[34]

6.4. Food Group Analysis

To explain what is driving the improvements in child diet quality, we examine child food consumption by food groups (Table 5). The outcome variables in Table 5 are dummy variables indicating whether the eligible child ate any food item in the respective food group in the past 24 hours. It is worth noting that the BCC program emphasized the importance of feeding animal products (Columns 1 to 3) and vitamin A-rich fruits and vegetables (Column 4). Food groups in Columns 5 to 7 were not emphasized in the BCC program.

Among children in the *BCC+Voucher* group, we find significant increases in children's consumption of food groups that the BCC program highlighted as important sources of micronutrients needed for healthy child growth. However, we find limited changes in the *BCC* and *Voucher* treatment group except for meat consumption. These results suggest that the greater improvements in diet quality in the *BCC+Voucher* group is driven by the greater

[34] Olney et al. (2015) show that BCC combined with agriculture input support and training increases the proportion of children meeting minimum dietary diversity by 12.6 percentage points, but do not report results on other child diet quality measures. A similar study that evaluates the impact of a nutrition education program coupled with agricultural intervention finds a 9.0 and 9.3 percentage point increase in the proportion of children meeting the minimum dietary diversity and the minimum acceptable diet standards, respectively, but no effect on CDDS (Reinbott et al., 2016). Fitzsimons et al. (2016) do not report results on CDDS, minimum dietary diversity, minimum acceptable diet, and minimum meal frequency. We find that the *BCC+Voucher* group was 17.6 and 15.3 percentage points more likely to meet the minimum dietary diversity and the minimum acceptable diet, respectively, in addition to positive and significant effects on CDDS and various meal frequency measures (Table A2).

consumption of animal source foods and vitamin A-rich fruits and vegetables among children in this group.

Changes in household expenditures explain the child diet results. Table A5 presents results household food expenditure per week per capita in total and by food groups.[35] Columns 1 and 2 present total household expenditure per week per capita on food and non-food items, respectively. Coefficients in Column 1 should equal to the sum of all expenditures by food group in Columns 3-11. It is worth noting that household food expenditures do not necessarily translate into child consumption if they are consumed only by other members of the household.

Firstly, for all treatment groups, we find positive coefficients on total food expenditures with effect sizes comparable to the voucher transfer amount (200 ETB $\div$ average household size of 4.5 $\div$ 4 weeks $\approx$ 11 ETB), but they are not statistically significant (Column 1). Also, we do not find any evidence for crowding out of food expenditures into non-food expenditures. If there is crowding out, we would expect to see both a decrease or a non-increase in food expenditures and an increase in non-food expenditures. However, none of the treatment groups exhibits this pattern.

Rather, we find that households in all treatment groups continue to spend more on non-staple food groups after the intervention including meat (Columns 3-11). Increased expenditure on meat, other fruits and vegetables, and nuts and legumes in the BCC group suggest that nutritional knowledge influences households to diversify food expenditure to some extent, even without additional income. For the Voucher group, expenditure increased only for meat. The

[35] Note that household expenditure data was collected during the follow-up survey which was conducted within one month after the completion of the interventions. Hence, household expenditure data do not include voucher expenditures.

BCC+Voucher group spent more on healthy non-staples such as meat and vitamin A-rich fruits and vegetables. Comparing across treatments, we find that BCC+Voucher spent significantly more on non-staple food than BCC, while there is little difference between BCC+Voucher and Voucher, and between BCC and Voucher.

6.5. Child Physical Growth

Lastly, we investigate the impacts on physical growth of children. Figure 5 presents HAZ score across the study groups at baseline and follow-up. We find that the overall HAZ scores decrease over the 6-month-period between baseline and follow-up without any treatment. Average HAZ score decreased from -1.03 to -1.63 and stunting prevalence increased from 28% to 42% in the control group from baseline to follow-up. This rapidly increasing pattern of stunting prevalence with age is similar to that of children over six months in developing countries.

Amid this rapidly increasing trend of undernutrition, we find undernutrition reduction in the *BCC+Voucher* group at least in the short run. Table 7 presents the results on HAZ score as well as stunting prevalence. Stunting prevalence significantly decreases by 9.8 percentage points among children in the *BCC+Voucher* group compared to the control group, while we do not find such evidence in single intervention groups (*BCC* and *Voucher* treatment groups).[36] Figure 5 further explains this result—the lower tail of the distribution shifted rightward rather than the upper tail, suggesting effects on stunting. This is in line with the large impact of *BCC+Voucher* on

[36] Stunting prevalence remained constant from baseline to follow-up for the *BCC+Voucher* group (30% at baseline and 30% at follow-up), while it increased for all other groups.

minimum acceptable diet in Section 6.2 (Table 4), a measure that also focuses on improvements in the lower tail of the distribution. Moreover, we find supportive evidence that *BCC+Voucher* prevented stunting from occurring during the critical age range from 12 to 18 months, rather than reversing stunting. Impacts on stunting status is driven main by those were not stunted at baseline.[37]

This result is in line with our conceptual framework which predicts that, if nutritional knowledge and inputs are mutually constraining—i.e., they are (near) perfect complements—then *Voucher* will have no impact, *BCC* will have no or moderate impact depending on budget constraint, and *BCC+Voucher* will have the greatest positive impact on child nutrition outcomes.

Other studies have yet to find evidence on the causal effect of BCC or BCC combined with other interventions on stunting reduction. Fitzsimons et al. (2016) find that BCC decreases wasting prevalence by 4.2 percentage points, significant at the 10% level, but do not show evidence for stunting reduction.[38] Other studies that coupled BCC with agricultural interventions do not find evidence for stunting reduction (Reinbott, et al., 2016; Olney, Pedehombga, Ruel, & Dillon, 2015). The null effect of *Voucher* on children's HAZ and stunting is consistent with most existing literature on cash transfer programs (Manley, Gitter, & Slavchevska, 2013).

6.7. Effects on Other Outcomes

[37] Conditional on not being stunted at baseline, stunting prevalence at follow-up was lower among children in the *BCC+Voucher* group (19%) than the control group (33%). However, conditional on being stunted at baseline, stunting prevalence at follow-up was similar, with 65% and 67% in the *BCC+Voucher* and the control groups, respectively (Figure A4).

[38] Wasting, low weight-for-height, indicates in most cases a recent and severe process of weight loss, which is often associated with acute starvation and/or severe disease. Stunting, on the other hand, is often a result of chronic suboptimal health and/or nutritional conditions.

Table 7 shows suggestive evidence for increases in mother's self-employed farming labor supply as a result of *BCC*. As most households in our sample are subsistence farmers, we examine whether mothers resort to other coping mechanisms, for example, homestead farming, in order to increase food resources. The increase in self-employed farming is statistically significant only for the *BCC* group by 7.7 percentage points. Though imprecisely measured, the number of hours worked in self-employed farming also increases by 2.5 hours per week for the *BCC* group. This shows that more mothers engage in income or food-generating activities when they learn about improved child-feeding practices but not given additional resources to do so. As most Ethiopian mothers' farming work is related to subsistence homestead or livestock farming, we can infer that *BCC* may have caused more mothers to engage in such farming to increase and diversify household food supply. This result is also in line with our finding that the *BCC* group managed to increase CDDS and FCS without necessarily decreasing non-food expenditures or increasing food expenditures. We do not find similar effects in other types of work including wage employment and self-employed commercial non-farming. Our results add to the finding in Malawi in which a six-month BCC intervention increased father's labor supply (Fitzsimon, Malde, Mesnard, & Vera-Hernandez, 2016).

7. Spillover Effects

We examine whether a one-time intervention could be sustained in the community through peer networks (Table 8). It is plausible that mothers primarily seek IYCF advice from their peers who gave birth just a few months ahead of them, in which case we expect the spillover group mothers who have a BCC-participating friend to be better-informed than those who do not. To assess this, we take advantage of the data on the spillover group which consists of mothers with children under 4 months and pregnant women at baseline. Column 1 of Table 9 presents the effect of having BCC friends defined by the networks of both the spillover group and BCC participants. Columns 2 and 3 show the effect of having BCC friends defined by the spillover group respondent's network and BCC participants' network, respectively.

We find suggestive evidence that knowledge on IYCF can be transferred to mother's peer group. Those in the spillover group who have a friend(s) who received the BCC treatment have higher IYCF knowledge score compared to those who do not. The coefficients are all positive and economically large even though the size and significance of the coefficients are different across the definition of the peer. Overall knowledge scores shown in Columns 1 and 3 increase by 0.35SD, 0.27SD, and 0.08SD, respectively, although statistically significant only in Column 2. It is also worth noting that the magnitude of this increase is approximately two-thirds of the increase among BCC participants.

8. Heterogeneity and Robustness Checks

8.1. Heterogeneity Analysis

We conduct heterogeneity analysis to assess whether treatment impacts differ by various household characteristics. We examine differences in the following baseline characteristics: knowledge score, CDDS, stunting status at baseline, exposure to child nutrition education, whether new mother (first child), child gender (female), asset score (above half), whether mother did not have any formal education, rural/urban, whether single mother, and whether mother has income. We analyze this by including the baseline characteristic of interest as control and interacting this dummy variable with the treatment group dummy variables.[39] Heterogenous effects on knowledge, CDDS, and stunting are presented in Figures A7 to A9. Overall, for the most part, we do not find statistically significant heterogeneous treatment effects by the baseline characteristics we examined.[40]

8.2. Robustness Checks

We also perform several robustness checks. First, to address the issue of small number of clusters, we use the wild-cluster bootstrap and randomization inference methods to for inference (Cameron, Gelbach, & Miller, 2008; Fisher, 1935; Rosenbaum, 2002). Our results show that the degrees of statistical significance do not differ for the most part when using the wild-cluster bootstrap and randomization inference p-values. As a second robustness check, we estimated all of the regressions in Tables 2 to 8 without control variables. We find that the results are robust

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[39] We test for heterogeneous treatment effects using the following specification: $y_{ij1} = \beta_0 + \beta_1 X_{ij0} BCC_{ij} + \beta_2 X_{ij0} Voucher_{ij} + \beta_3 X_{ij0} BCC\&Voucher_{ij} + \beta_4 BCC_{ij} + \beta_5 Voucher_{ij} + \beta_6 BCC\&Voucher_{ij} + \beta_7 X_{ij0} + \beta_8 y_{ij0} + \varepsilon_{ij}$. y_{ij} is the outcome of interest for household *i* from village *j*. BCC_{ij}, $Voucher_{ij}$, and $BCC\&Voucher_{ij}$ are treatment indicators equal to one for households living in treated villages, and X_{ij0} is a dummy variable for the baseline characteristic of interest. Thus, the coefficients β_1, β_2, and β_3 on the interaction between the baseline characteristic dummy and the treatment variables represent the heterogenous treatment effects. Standard errors are clustered at the village level, the unit of randomization.

[40] Among the few heterogeneous impacts we find, the positive impact of *BCC+Voucher* is significantly smaller for female children and greater for children from poor households. We find that mother's IYCF knowledge was lower among mothers of girls in the *BCC+Voucher* group, and higher among mothers from poor households for *BCC+Voucher* (Figure A7). CDDS is lower for children of new mothers and poor households in *BCC+Voucher* (Figure A8). Stunting prevalence is significantly higher for female children but lower among the poor in the *BCC+Voucher* group (Figure A9). Note that we do not find differential impacts by being a new mother (i.e., first time having a child) or being stunted at baseline. On other characteristics that we examined but not reported, we do not find evidence for heterogeneous effects.

to the exclusion of control variables, and the point estimates and their degree of statistical significance remain similar.

9. Cost-effectiveness Analysis

We carried out a cost-effectiveness analysis on statistically significant differences relative to the control group in impact on stunting.[41] The outcomes for this analysis include cost per case of stunting averted and per disability-adjusted life years (DALY) averted.[42] The number of cases of stunting averted by the intervention relative to the control group were calculated using the associated point estimate reported in Table 7, and the total population of children in intervention and control villages.

Program cost data were extracted from AFF accounting ledgers to assess costs associated with the *BCC+Voucher* intervention. Costs were assessed over the full implementation period of the *BCC+Voucher* intervention, September 2017 to February 2018, starting from village and beneficiary household selection and 4 months of program implementation. Start-up costs and intervention piloting costs were not included, and cost structures represent a mature program. Costs incurred outside of the intervention period were not assessed. All costs are expressed in

[41] Cost-effectiveness analysis is conducted for the *BCC+Voucher* intervention only because the intent-to-treat impact of the interventions on stunting is statistically significant for this group only.

[42] DALY is an index used to measure health outcomes which consists of years of life lost (YLL) and years lived with disability (YLD). We assume that the age at onset of stunting to be the average children age at follow-up, i.e., 18 months, and the duration of illness to be lifelong. Life-expectancy was calculated as a sex-weighted average using local life expectancy of males (63.7) and females (67.3) (WHO 2018). The disability weight for stunting (0.0002) was taken from the Global Burden of Disease study published in 1990 (Murray and Lopez 1996) and retained in subsequent studies. The disability weight for death is 1.000. To calculate YLL, expected mortality was calculated using the under 5-year mortality rate (UNICEF 2018) adjusted to exclude mortality in children aged less than 1 year (You et al. 2015) and mortality due to stunting (McDonald et al. 2013). YLL and YLD components were calculated and summed to estimate the number of DALY averted for *BCC+Voucher*.

2018 US dollars and exchange rates varied monthly. Costs were not adjusted for inflation due to interventions lasting less than one year.

Total costs of the *BCC+Voucher* intervention is presented in Table 8, including program costs and costs borne by program participants. The *BCC+Voucher* intervention with 154 program participants had a total cost of US$11,712 with 84% of the total cost attributed to program operational and transfer costs and 16% borne by program participants. Costs of implementing the 16-week-long BCC program were US$3,063 with most costs related to personnel. Implementation costs for the voucher program, including the transfers, were US$5,544. The actual transfer amount accounted for 82% of the voucher program costs.

The direct and indirect costs borne by *BCC+Voucher* participants include transportation fares and time participating in the BCC sessions.[43] Average transportation cost to BCC session locations was US$0.36 per roundtrip for *BCC+Voucher* participants which was multiplied by 16 BCC sessions. Average time cost for participating in the BCC sessions was US$0.21 per hour for *BCC+Voucher* participants, multiplied by 16 hourly BCC sessions. Based on household surveys, we estimated that a roundtrip from house to BCC session took one hour. No cost was incurred for the control group.

On average, the total cost of *BCC+Voucher* per household was US$76 and approximately US$15 per month (Table 8). This cost is considerably lower than other similar integrated nutrition

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[43] We did not consider travel and time costs for voucher distribution because voucher was distributed at the participants' closest market to which she would have traveled regardless of voucher distribution for personal grocery shopping. When the participant didn't obtain the vouchers from the market, voucher staff visited their household.

programs.[44] The cost per case of stunting averted by *BCC+Voucher* was US$776 and cost per DALY was US$265 which is considered highly cost-effective in WHO standards (WHO 2014).

10. Discussion and Conclusion

High rates of stunting in many developing countries pose important health threats to young children. Many interventions that target a single dimension of causes of child undernutrition have often found limited effects. Interventions that address multidimensional and interrelated causes of undernutrition, such as lack of awareness and affordability, may be more effective in bringing about healthy child development. We test this by implementing a community-based cluster randomized experiment in Ethiopia that randomly provides IYCF education through a nutrition BCC and income through food vouchers to mothers of children aged between 4 and 20 months.

We find that providing nutrition education only (BCC) or voucher only (Voucher) has limited effects on improving child-feeding practices and child growth. BCC is effective for specific behaviors with which there is little or no cost associated—e.g., adjusting the age of introducing complementary food. Also, BCC mothers may increase their self-employed farming labor supply to procure additional food. We also find vouchers could lead to increases in the non-staple food stock in the household, but they are not allocated to children in the absence of nutritional knowledge. However, when provided both education and voucher, mothers allocate the healthy non-staple food purchased to infant and young children, leading to improvements in nutritional status. In particular, we demonstrate that BCC+Voucher is effective for improving child physical

[44] For example, Rwanda's Gikuriro, an integrated nutrition program funded by the USAID and implemented by Catholic Relief Services, cost US$142 per household and find no effect on stunting (McIntosh and Zeitlin, 2018).

growth by preventing chronic undernutrition rather than reversing it. We explore spillover effects as possible channels for information transfers to non-participating mothers.

These results confer important policy implications. First, for programs aiming to improve suboptimal health behaviors, it is crucial not only to identify the key constraints, but also to understand the underlying relationship between the constraints. If the key constraints are complementary, an effective program will require a multifaceted approach that relaxes multiple constraints simultaneously, as demonstrated in this study. Second, for social protection or nutrition programs aiming to reduce child undernutrition, it may be best to target infant and young children in the critical age range of six to 18 months, including those who are not undernourished, as BCC+Voucher is particularly effective in preventing stunting from occurring in this age range rather than reversing it.

This study has some limitations. First, our study looks at relatively short-term results measured during the period between completion of the intervention and three months thereafter. Thus, we are not able to examine whether improved knowledge and IYCF practices are sustained in the long-term, and whether or not chronic nutritional status improves further with time. Secondly, there are only 79 villages (clusters) in our study sample with 13-15 villages per treatment group and 37 villages in the control group, which we address by small-sample correction of standard errors using Wild-cluster bootstrapping and randomization inference methods. The results should be interpreted with this caveat.

Our results show that both awareness and affordability are intertwined challenges for improved IYCF which is critical for preventing stunted growth. We also demonstrate that addressing either one of these challenges has no or moderate effect on improving child-feeding practices. The impacts on IYCF are greatest when both knowledge and financial constraints are addressed simultaneously, leading to stunting reduction.

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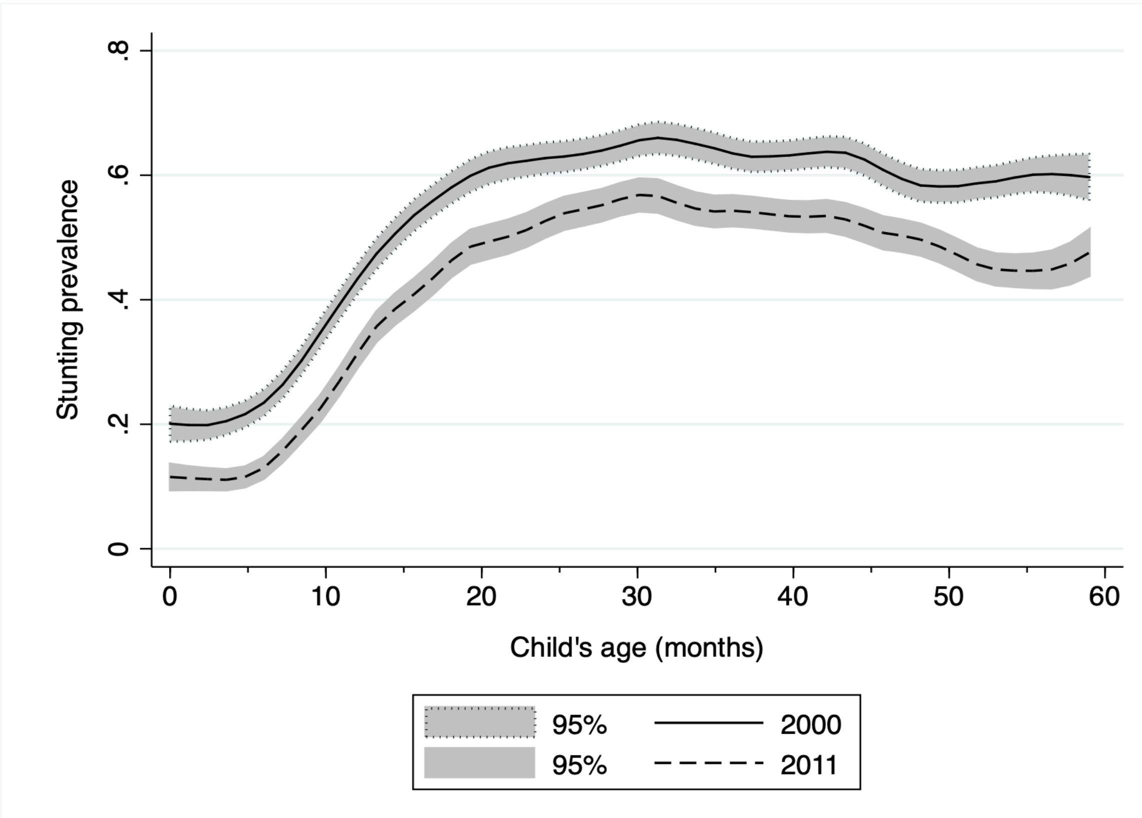
Figures and Tables

Figure 1: Stunting Prevalence by Child Age in Ethiopia



Source: Local polynomial smoothing predictions with 95% confidence intervals estimated using the DHS data (Ethiopia DHS, 2000, 2011).

Figure 2: Study Design

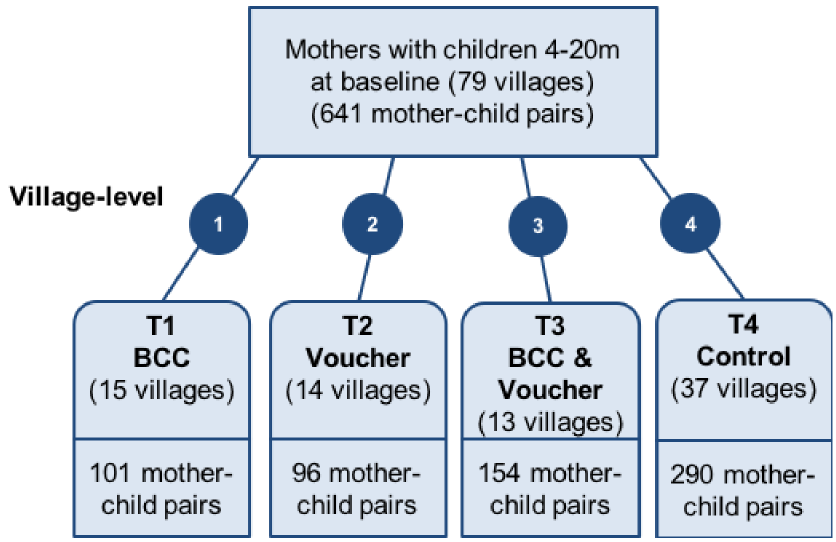
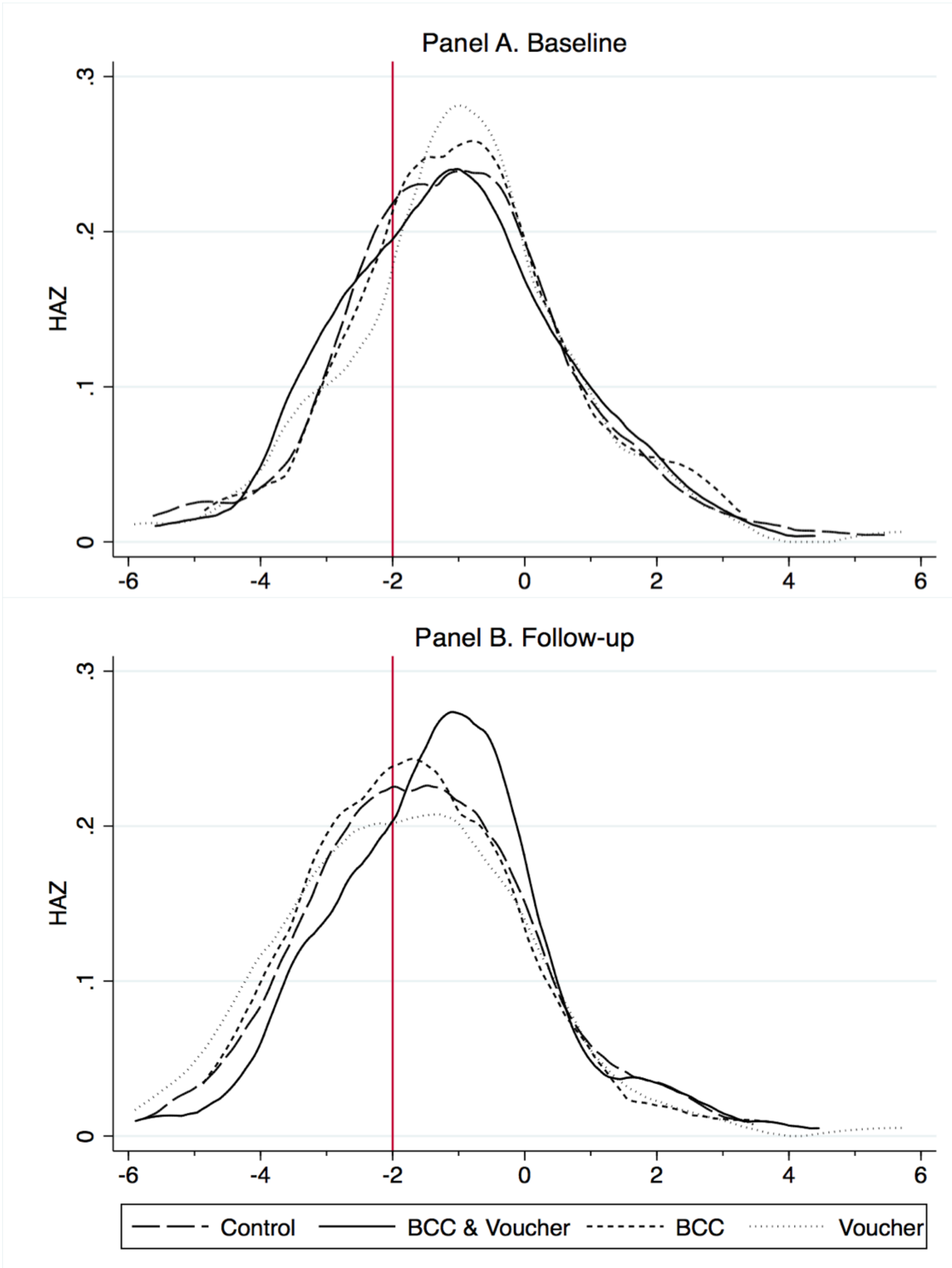


Figure 3: Distribution of Height-for-age Z Score (HAZ) at Baseline and Follow-up



Note: This figure presents kernel density graph of height-for-age Z scores of eligible child at baseline (Panel A) and at follow-up (Panel B). The red vertical line represents -2SD, below which means stunted growth, an indicator for chronic undernutrition.

Table 1: Baseline Mean Characteristics by Intervention Groups

	Mean		Difference between treatment and control			P-value:	N	Difference between treatments		
	All	Control	B-C	V-C	BV-C	B=V=BV		B-V	B-BV	V-BV
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Panel A. Mother characteristics										
Mother age (years)	28.29	28.21	-0.656	-0.028	0.777	0.495	639	0.684	1.433	0.749
Mother is Oromo	0.766	0.765	-0.013	0.005	0.007	0.886	641	0.018	0.020	0.002
Mother is Orthodox Christian	0.844	0.851	0.0010	0.002	-0.040	0.912	641	-0.007	-0.050	-0.042
Mother is married	0.768	0.778	-0.046	-0.049	0.020	0.969	640	-0.004	0.066	0.070
Mother has work	0.564	0.543	0.049	0.039	0.027	0.917	641	-0.011	-0.023	-0.012
Mother able to read	0.495	0.471	0.085	0.052	0.015	0.722	640	-0.034	-0.071	-0.037
Mother able to write	0.485	0.457	0.089	0.055	0.028	0.734	640	-0.034	-0.061	-0.027
Mother years of schooling	4.258	3.958	0.748	-0.216	0.919	0.434	641	-0.964	0.171	1.134
Mother IYCF knowledge score	21.49	21.46	0.050	-0.132	0.198	0.796	641	-0.183	0.148	0.330
Panel B. Child characteristics										
Eligible child age (months)	12.48	12.29	1.115**	-0.029	0.053	0.083	641	-1.144*	-1.062*	0.082
Child dietary diversity score	2.359	2.433	0.027	-0.219	-0.198	0.316	641	-0.247	-0.225	0.022
Minimum acceptable diet	0.128	0.116	0.072	0.001	0.001	0.251	634	-0.071	-0.071	0.000
Height-for-age Z score	-1.060	-1.038	-0.042	-0.037	-0.053	0.985	619	0.005	-0.010	-0.016
Stunting	0.272	0.266	0.002	-0.018	0.036	0.785	619	-0.020	0.034	0.054
Panel C. Household characteristics										
Female household head	0.139	0.135	0.024	0.001	0.002	0.671	641	-0.023	-0.022	0.001
Household size	4.539	4.495	-0.094	0.198	0.110	0.252	641	0.292	0.204	-0.088
Number of children	2.348	2.315	-0.103	0.127	0.114	0.408	641	0.230	0.217	-0.013
Asset index	-0.015	-0.057	0.178	-0.054	0.077	0.574	641	-0.232	-0.101	0.131
Rural	0.445	0.505	-0.022	-0.069	-0.195	0.830	641	-0.048	-0.173	-0.126
Total weekly food expenditure, per capita	131.2	129.9	12.653	-9.367	0.734	0.579	641	-22.020	-11.919	10.101
Total weekly non-food expenditure, per capita	38.92	39.86	2.122	-9.671	0.988	0.284	641	-11.79*	-1.134	10.659
Household food consumption score	43.19	43.28	-1.076	0.144	0.164	0.599	641	1.220	1.240	0.020
Panel D. Attrition										
Follow-up Survey Attrition Rates	0.084	0.093	0.006	-0.041	-0.015	0.260	641	-0.047	-0.021	0.026
Anthropometry Attrition Rates	0.165	0.161	0.047	-0.054	0.017	0.085	641	-0.10**	-0.030	0.071
Joint test (p-value)			0.066	0.495	0.122					

This table reports mean of selected baseline variables and OLS estimates of baseline differences in treatment arms. Outcome variables are listed on the left, and for each outcome variable, we report the coefficients of interest. Columns 1-2 show a summary of the whole sample and the control group. Columns 3-5 report mean differences and significance levels from test of mean differences between each treatment group and control. Column 6 shows p-values from the joint test of equality of parameters reported in columns 3-5, column 7 the number of observations, and columns 8-10 test of mean differences between treatment groups. The last row shows p-values from F-test of joint significance of the coefficients in the corresponding column. *, **, and *** denote significance at 10%, 5%, and 1%, respectively. B=BCC, V=Voucher, BV=BCC+Voucher.

Table 2: Effects on BCC Attendance and Mother IYCF Knowledge

	BCC Attendance rate	Mother IYCF knowledge score (standardized)
	(1)	(2)
BCC (B)	0.727***	0.477***
	(0.022)	(0.097)
		[0.000]
		{0.000}
Voucher (V)	-0.004	0.070
	(0.007)	(0.134)
		[0.607]
		{0.657}
BCC & Voucher (BV)	0.754***	0.419***
	(0.013)	(0.096)
		[0.000]
		{0.004}
Observations	637	584
R-squared	0.898	0.127
Control group mean	0.000	-0.166
P-value: B=V		0.006
P-value: B=BV	0.304	0.601
P-value: V=BV		0.024
P-value: B+V=BV		0.482

This table reports results on overall BCC attendance rate and mothers' IYCF knowledge score (standardized). Column 1 uses administrative data collected during intervention and compares BCC attendance rates with the control group where the control and the voucher group's attendance rates are zero. Column 2 uses survey data on mothers' IYCF knowledge collected after intervention completion. All estimations include area dummies, mother's age, whether mother is married, working, able to read, and able to write, mother's years of schooling, eligible child age, household size, number of children, whether female-headed household, household asset index, ethnicity, and religion. Column 2 additionally controls for the baseline outcome. Robust standard errors clustered at the unit of randomization, the village level, in parentheses. Wild-cluster bootstrap p-values in square brackets. Randomization inference p-values in curly brackets. The last four rows report p-values from F-tests of coefficient equality between treatment groups. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 3: Effects on Voucher Redemption
(During Intervention)

	Average monthly total voucher exp.	Average voucher redemption per week by food group								
		Meat and fish	Milk and milk products	Eggs	Vitamin A-rich fruits & veg.	Other fruits and veg.	Nuts and legumes	Starchy staples	Oil and fats	Sugar, drinks, and spices
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Voucher (V)	176.2***	0.142	0.078*	1.407***	1.208***	5.992***	1.980***	17.849***	12.016***	3.325***
	(4.534)	(0.091)	(0.040)	(0.277)	(0.134)	(0.439)	(0.418)	(0.922)	(0.860)	(0.255)
	[0.000]	[0.014]	[0.038]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
	{0.000}	{0.024}	{0.003}	{0.001}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}	{0.000}
BCC & Voucher (BV)	173.4***	0.031	0.121**	1.131***	1.425***	7.836***	1.500***	16.104***	11.625***	3.491***
	(3.561)	(0.027)	(0.046)	(0.166)	(0.142)	(0.433)	(0.448)	(0.712)	(0.551)	(0.196)
	[0.000]	[0.285]	[0.042]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]	[0.000]
	{0.000}	{0.511}	{0.041}	{0.001}	{0.000}	{0.000}	{0.005}	{0.000}	{0.000}	{0.000}
Observations	523	523	523	523	523	523	523	523	523	523
R-squared	0.926	0.071	0.033	0.260	0.390	0.622	0.317	0.672	0.656	0.429
P-value: V=BV	0.639	0.219	0.405	0.339	0.274	0.006	0.386	0.132	0.695	0.563

This table reports results on average voucher redemption in total per month and by food groups per week using the voucher purchase administrative data collected during the intervention. Using the voucher administrative data, the results compare the $BCC + Voucher$ group and the $Voucher$ group with the control group which has zero voucher spending. All estimations control for area dummies, mother's age, whether mother is married, working, able to read, and able to write, mother's years of schooling, eligible child age, household size, number of children, whether female-headed household, household asset index, ethnicity, and religion. Robust standard errors clustered at the unit of randomization, the village level, in parentheses. Wild-cluster bootstrap p-values in square brackets. Randomization inference p-values in curly brackets. The last row reports p-value from an F-test of coefficient equality between $Voucher$ and $BCC + Voucher$ groups. *** p<0.01, ** p<0.05, * p<0.1.

Table 4: Effects on Child Diet Quality
(After Intervention Completion)

	CDDS	Minimum acceptable diet	Timely intro. of complementary food score (standardized)	Perceived relative child dietary quality	Standardized treatment effect
	(1)	(2)	(3)	(4)	(5)
BCC (B)	0.332*	0.085**	0.144**	0.037	0.052***
	(0.172)	(0.035)	(0.064)	(0.027)	(0.017)
	[0.083]	[0.038]	[0.048]	[0.197]	
	{0.108}	{0.127}	{0.061}	{0.267}	
Voucher (V)	0.005	-0.002	-0.035	0.052**	0.008
	(0.185)	(0.030)	(0.084)	(0.025)	(0.015)
	[0.978]	[0.950]	[0.709]	[0.046]	
	{0.991}	{0.969}	{0.697}	{0.115}	
BCC & Voucher	0.589***	0.153***	0.134**	0.077***	0.084***
(BV)	(0.167)	(0.030)	(0.061)	(0.023)	(0.014)
	[0.015]	[0.001]	[0.086]	[0.003]	
	{0.004}	{0.004}	{0.069}	{0.005}	
Observations	583	537	572	584	2276
R-squared	0.121	0.122	0.043	0.068	0.050
Control group mean	3.073	0.124	0.153	0.905	0.000
P-value: B=V	0.117	0.025	0.064	0.544	0.011
P-value: B=BV	0.186	0.088	0.317	0.119	0.070
P-value: V=BV	0.006	0.000	0.079	0.262	0.000
P-value: B+V=BV	0.353	0.180	0.822	0.735	0.308

This table reports results on child dietary diversity score (CDDS), minimum acceptable diet standard, standardized score on timely introduction of complementary foods, and mothers' perception of their child's relative dietary quality, collected after intervention completion. All estimations include the baseline outcome, area dummies, mother's age, whether mother is married, working, able to read, and able to write, mother's years of schooling, eligible child age, household size, number of children, whether female-headed household, household asset index, ethnicity, and religion. Robust standard errors clustered at the unit of randomization, the village level, in parentheses. Wild-cluster bootstrap p-values in square brackets. Randomization inference p-values in curly brackets. The last four rows report p-values from F-tests of coefficient equality between treatment groups. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 5: Effects on Child Food Consumption
(After Intervention Completion)

	Whether child ate in the last 24 hours:						
	Meat	Milk	Eggs	Vitamin A-rich fruits & veg.	Other fruits & veg.	Nuts & legumes	Starchy staples
	(1)	(2)	(3)	(5)	(6)	(7)	(8)
BCC (B)	0.135***	0.083*	0.078	-0.001	-0.019	0.075	-0.023
	(0.051)	(0.046)	(0.063)	(0.055)	(0.059)	(0.056)	(0.017)
	[0.030]	[0.102]	[0.296]	[0.988]	[0.797]	[0.182]	[0.218]
	{0.001}	{0.151}	{0.150}	{0.974}	{0.742}	{0.249}	{0.123}
Voucher (V)	0.137***	-0.032	-0.019	-0.062	-0.038	0.022	-0.003
	(0.037)	(0.046)	(0.070)	(0.041)	(0.053)	(0.069)	(0.013)
	[0.003]	[0.513]	[0.791]	[0.145]	[0.506]	[0.775]	[0.881]
	{0.000}	{0.583}	{0.767}	{0.278}	{0.506}	{0.749}	{0.876}
BCC & Voucher	0.123***	0.092**	0.183***	0.096**	0.007	0.074	0.005
(BV)	(0.023)	(0.043)	(0.052)	(0.048)	(0.044)	(0.046)	(0.009)
	[0.000]	[0.058]	[0.014]	[0.100]	[0.884]	[0.149]	[0.680]
	{0.000}	{0.147}	{0.005}	{0.095}	{0.903}	{0.244}	{0.713}
Observations	583	583	583	583	583	583	583
R-squared	0.107	0.091	0.095	0.059	0.042	0.047	0.037
Control group mean	0.119	0.275	0.286	0.226	0.805	0.368	0.992
P-value: B=V	0.981	0.029	0.242	0.296	0.769	0.467	0.248
P-value: B=BV	0.813	0.852	0.139	0.128	0.687	0.995	0.123
P-value: V=BV	0.735	0.016	0.013	0.003	0.414	0.444	0.563
P-value: B+V=BV	0.023	0.549	0.233	0.038	0.452	0.806	0.187

This table reports results on child food consumption by food group. Each outcome indicates whether the child ate any food from the food group in the last 24 hours, collected after intervention completion. The 'Animal products' food group is an aggregation of meat and fish, milk and milk products, and eggs. All estimations control for the baseline outcome, area dummies, mother's age, whether mother is married, working, able to read, and able to write, mother's years of schooling, eligible child age, household size, number of children, whether female-headed household, household asset index, ethnicity, and religion. Robust standard errors clustered at the unit of randomization, the village level, in parentheses. Wild-cluster bootstrap p-values in square brackets. Randomization inference p-values in curly brackets. The last four rows report p-values from F-tests of coefficient equality between treatment groups. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 6: Effects on Child Physical Growth
(After Intervention Completion)

	HAZ (1)	Stunted (2)	WHZ (3)	Wasted (4)
BCC (B)	-0.054	0.079	0.318*	-0.040
	(0.173)	(0.073)	(0.160)	(0.033)
	[0.759]	[0.322]	[0.048]	[0.269]
	{0.678}	{0.151}	{0.037}	{0.237}
Voucher (V)	-0.181	0.068	-0.028	-0.002
	(0.154)	(0.059)	(0.153)	(0.035)
	[0.289]	[0.308]	[0.837]	[0.962]
	{0.123}	{0.139}	{0.443}	{0.854}
BCC & Voucher (BV)	0.173	-0.098**	-0.021	0.016
	(0.157)	(0.045)	(0.179)	(0.033)
	[0.398]	[0.085]	[0.908]	[0.625]
	{0.284}	{0.099}	{0.823}	{0.646}
Observations	490	490	499	499
R-squared	0.334	0.235	0.133	0.080
Control group mean	-1.543	0.416	0.026	0.082
P-value: B=V	0.539	0.908	0.054	0.401
P-value: B=BV	0.221	0.019	0.101	0.184
P-value: V=BV	0.073	0.017	0.976	0.679
P-value: B+V=BV	0.096	0.012	0.247	0.288

This table reports results on height-for-age Z scores (HAZ), stunting prevalence, weight-for-height Z scores (WHZ), and wasting prevalence, collected after intervention completion. All estimations include baseline outcome, area dummies, mother's age, whether mother is married, working, able to read, and able to write, mother's years of schooling, eligible child age, household size, number of children, whether female-headed household, household asset index, ethnicity, and religion. Robust standard errors clustered at the unit of randomization, the village level, in parentheses. Wild-cluster bootstrap p-values in square brackets. Randomization inference p-values in curly brackets. The last four rows report p-values from F-tests of coefficient equality between treatment groups. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 7: Effects on Mother's Self-employed Farming Labor Supply

	Whether mother engaged in self-employed farming	Hours worked per week by mother on self-employed farming
	(1)	(2)
BCC (B)	0.095**	2.519*
	(0.041)	(1.395)
	[0.040]	[0.114]
	{0.056}	{0.249}
Voucher (V)	0.021	0.544
	(0.045)	(1.503)
	[0.694]	[0.748]
	{0.839}	{0.883}
BCC & Voucher (BV)	0.034	1.166
	(0.042)	(1.403)
	[0.464]	[0.452]
	{0.930}	{0.972}
Observations	507	507
R-squared	0.370	0.311
Control group mean	0.271	8.996
P-value: B=V	0.110	0.182
P-value: B=BV	0.209	0.360
P-value: V=BV	0.803	0.705
P-value: B+V=BV	0.240	0.395

This table reports results on whether mothers engaged in self-employed farming in the last month and the number of hours worked on self-employed farming in the last week. All estimations control for the baseline outcome, area dummies, mother's age, whether mother is married, working, able to read, and able to write, mother's years of schooling, eligible child age, household size, number of children, whether female-headed household, household asset index, ethnicity, and religion. Robust standard errors clustered at the unit of randomization, the village level, in parentheses. Wild-cluster bootstrap p-values in square brackets. Randomization inference p-values in curly brackets. The p-value for difference in coefficients is a F-test for whether the coefficient differs between treatment groups. The p-value for difference between B+V and BV tests whether there is any complementarity between BCC and vouchers. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 8: Spillover Effects

	(1)	(2)	(3)
Peer definitions:	Mutually listed as friends	BCC participant listed spillover group mother as friend	Spillover group mother listed BCC participant as friend
Dependent variable:	Mother IYCF knowledge score (standardized)		
# of BCC peers	0.111	0.182*	0.071
	(0.305)	(0.103)	(0.104)
Observations	275	275	275
R-squared	0.112	0.120	0.113

This table reports results on the number of BCC-participating peers spillover group mother has defined by both the spillover group and BCC-participating mother networks (Column 1), the BCC-participating mothers' networks (Column 2), and the spillover group mothers' networks (Column 3). All estimations control for the baseline outcome, area dummies, mother's age, whether mother is married, pregnant, working, able to read, and able to write, mother's years of schooling, total number of friends listed as network, eligible child age, household size, number of children, whether female-headed household, household asset index, ethnicity, and religion. Robust standard errors clustered at the unit of randomization, the village level, in parentheses. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table 9: $BCC + Voucher$ Cost-effectiveness Analysis

	Amount (USD)	% of Total
BCC		
Personnel	1,110	9.5%
Community workers	640	5.5%
Personnel transportation	419	3.6%
Training materials	614	5.2%
Other program costs	281	2.4%
BCC subtotal	3,063	26.2%
Voucher		
Transfer amount	5,544	47.3%
Personnel	430	3.7%
Personnel transportation	479	4.1%
Community workers	274	2.3%
Voucher subtotal	6,727	57.4%
Beneficiary cost		
Transportation	887	7.6%
Time	1,035	8.8%
Beneficiary cost subtotal	1,922	16.4%
TOTAL	11,712	
Total cost per household		US$ 76
Decrease in prevalence of stunting		9.8%
Cases of stunting averted		15
Cost per case of stunting averted		US$ 776
DALY averted		44
Cost per DALY averted		US$ 265

Appendices

Appendix A Figures and Tables

Figure A1: Study Timeline

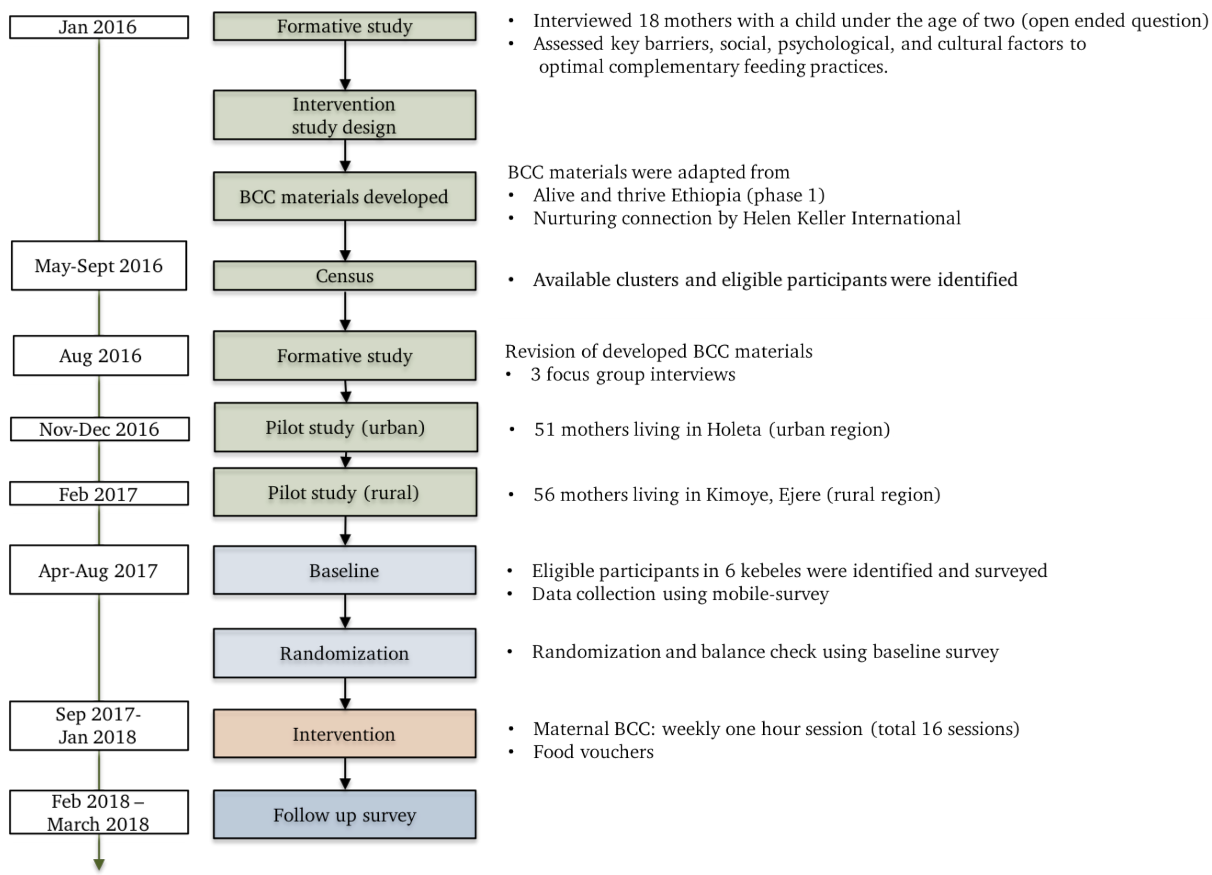


Figure A2: Map of Ejere District

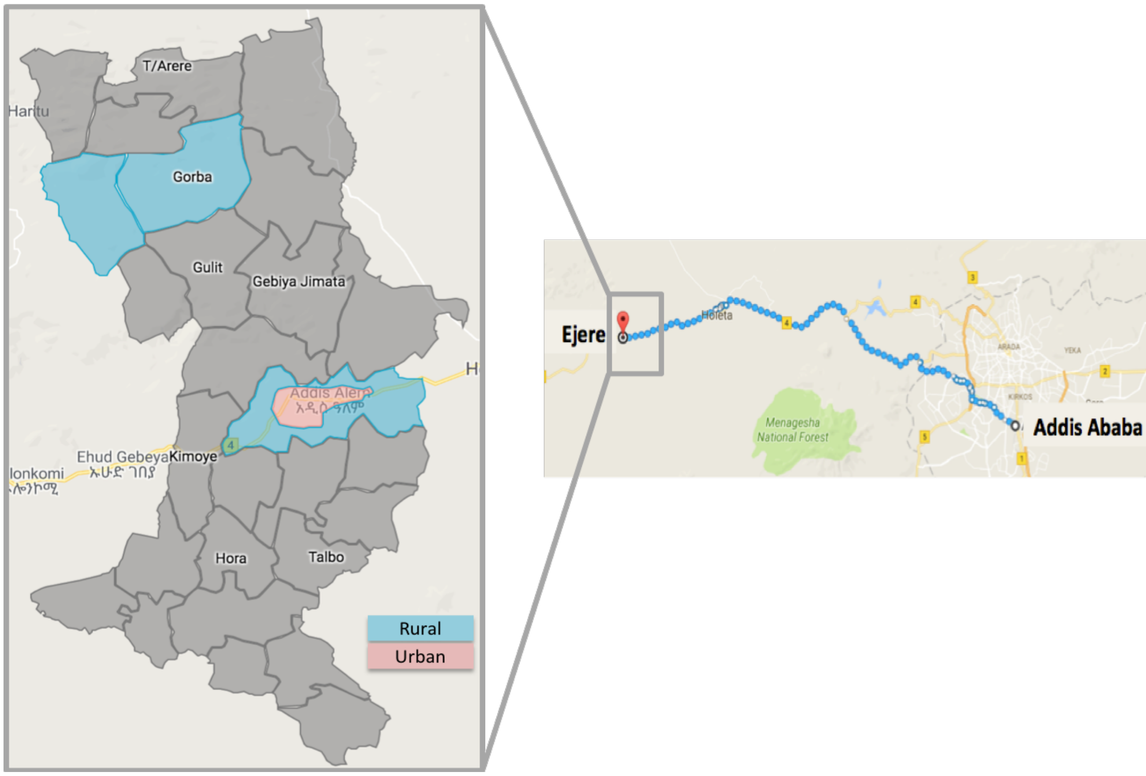
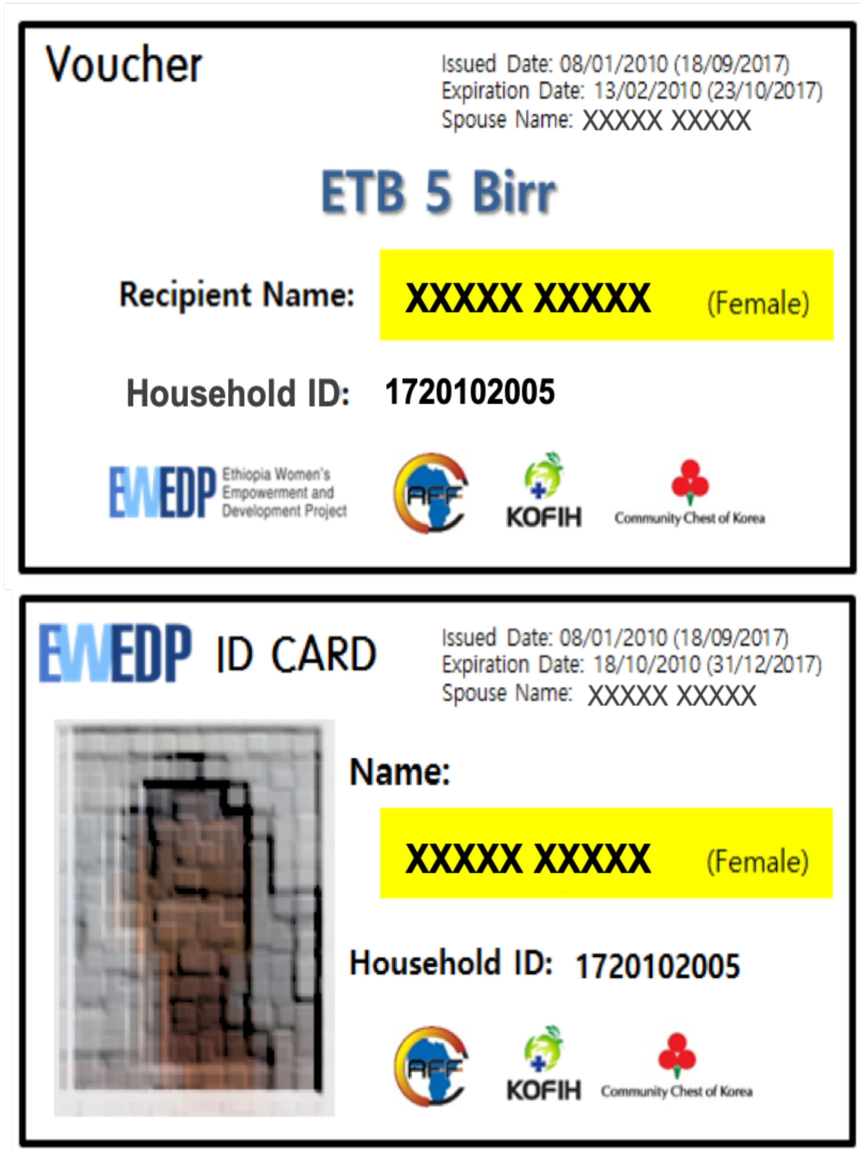


Figure A3: Sample Voucher and Household ID

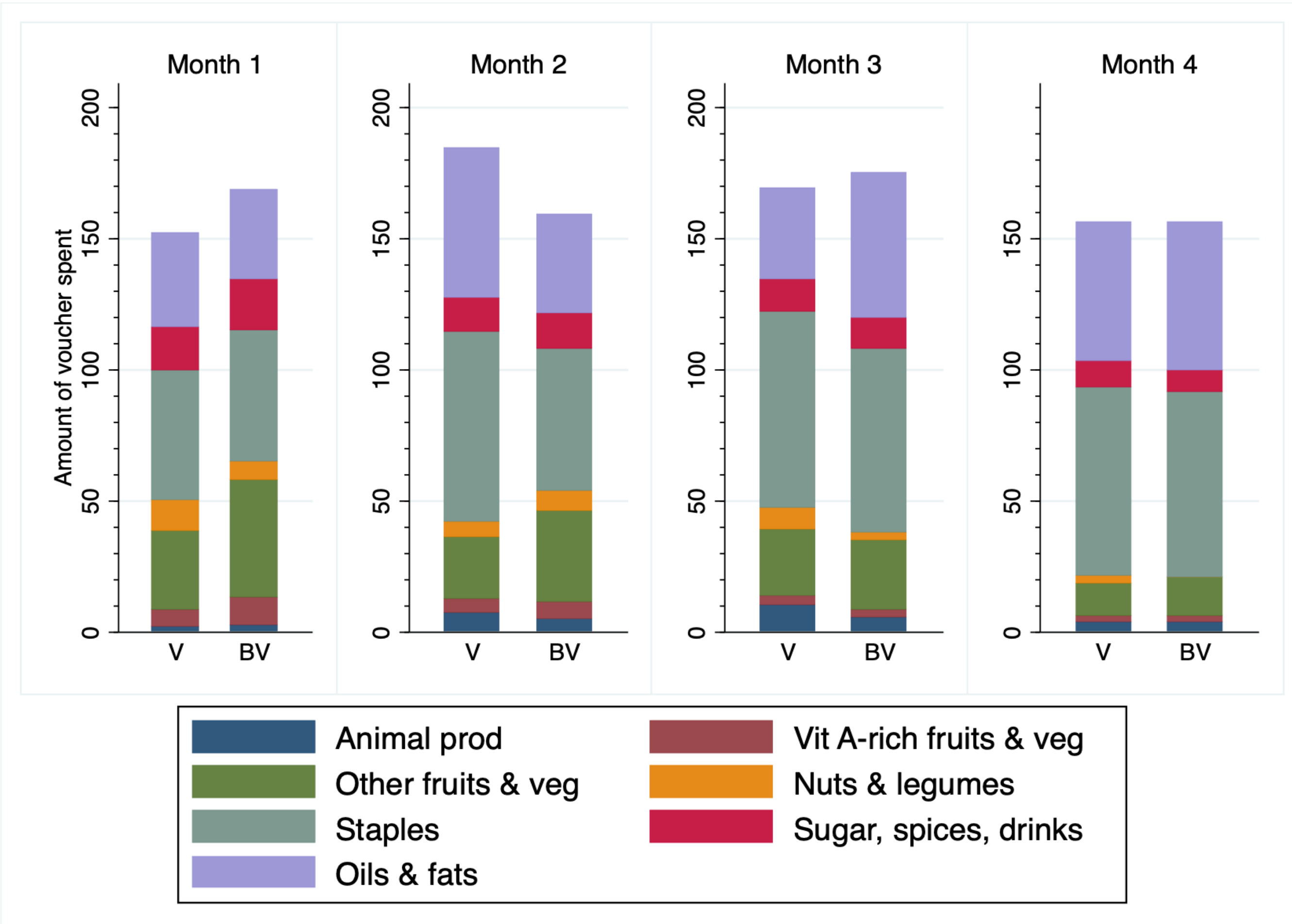


Note: This figure shows sample voucher and household ID provided to the *Voucher* and *BCC + Voucher* households. Each voucher and the household ID state the recipient name, unique household ID, and spouse name which are cross-checked for verification in voucher transactions. They also list the issued date and expiration date in Ethiopian calendar, with dates in Gregorian calendar in parentheses. Before distribution, these vouchers and ID cards were printed and stamped in blue with an official AFF mark to prevent duplication.

Figure A4: Voucher Redemption Patterns Over Time
(During Intervention)

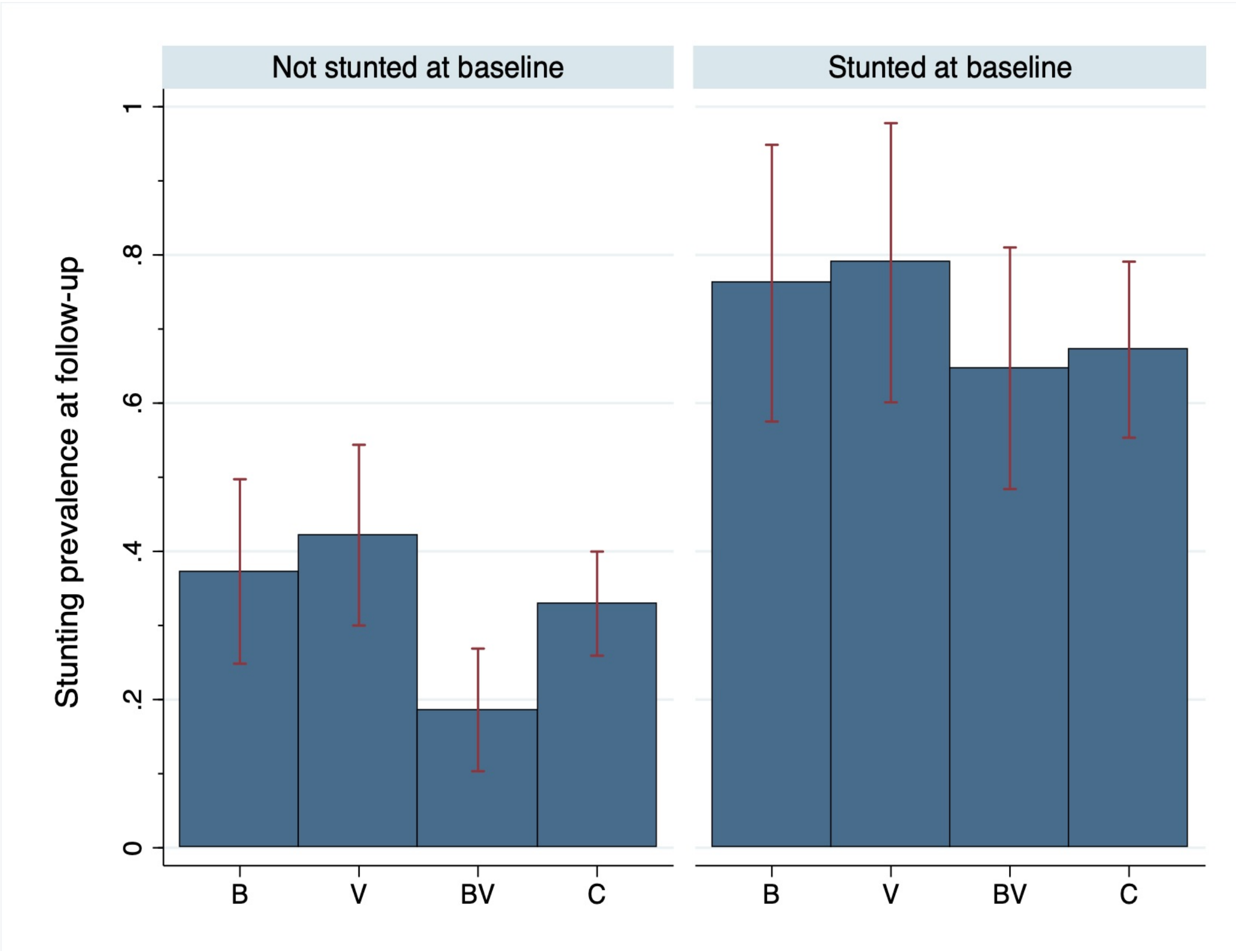
Note: This figure shows total amount of vouchers spent per week over time on average across both BCC and $BCC + Voucher$ groups, using voucher purchase administrative data. The horizontal axis ranges from week 1 to 16. Bars are grouped in 4 weeks, indicating each month.

Figure A5: Voucher Redemption Patterns Over Time by Treatment and Food Group (During Intervention)



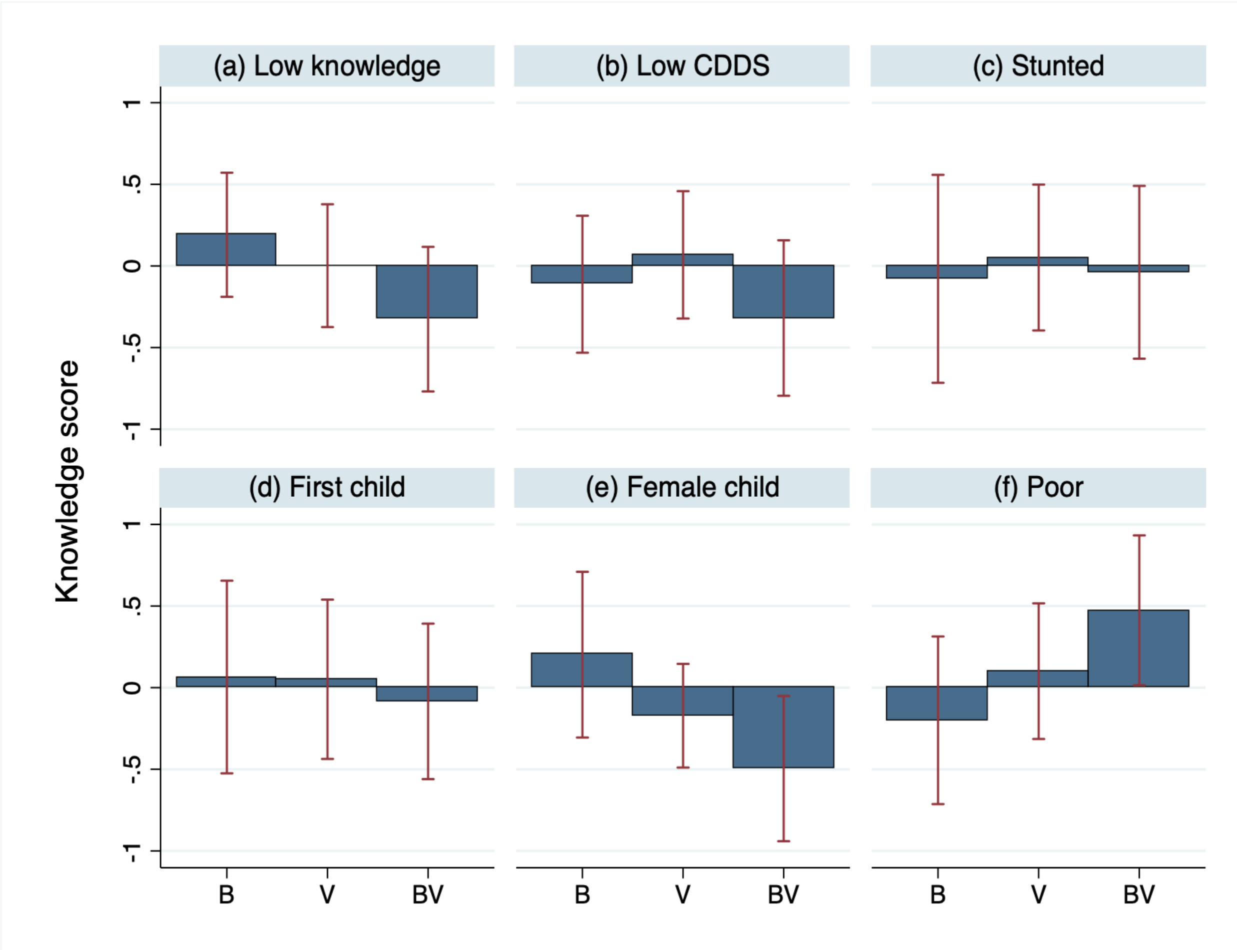
Note: This figure shows monthly voucher expenditures by food group and by treatment groups from month 1 (weeks 1-4) to month 4 (weeks 13-16), using voucher purchase administrative data. V=Voucher, BV=BCC+Voucher.

Figure A6: Stunting Prevalence at Follow-up by Stunting Status at Baseline



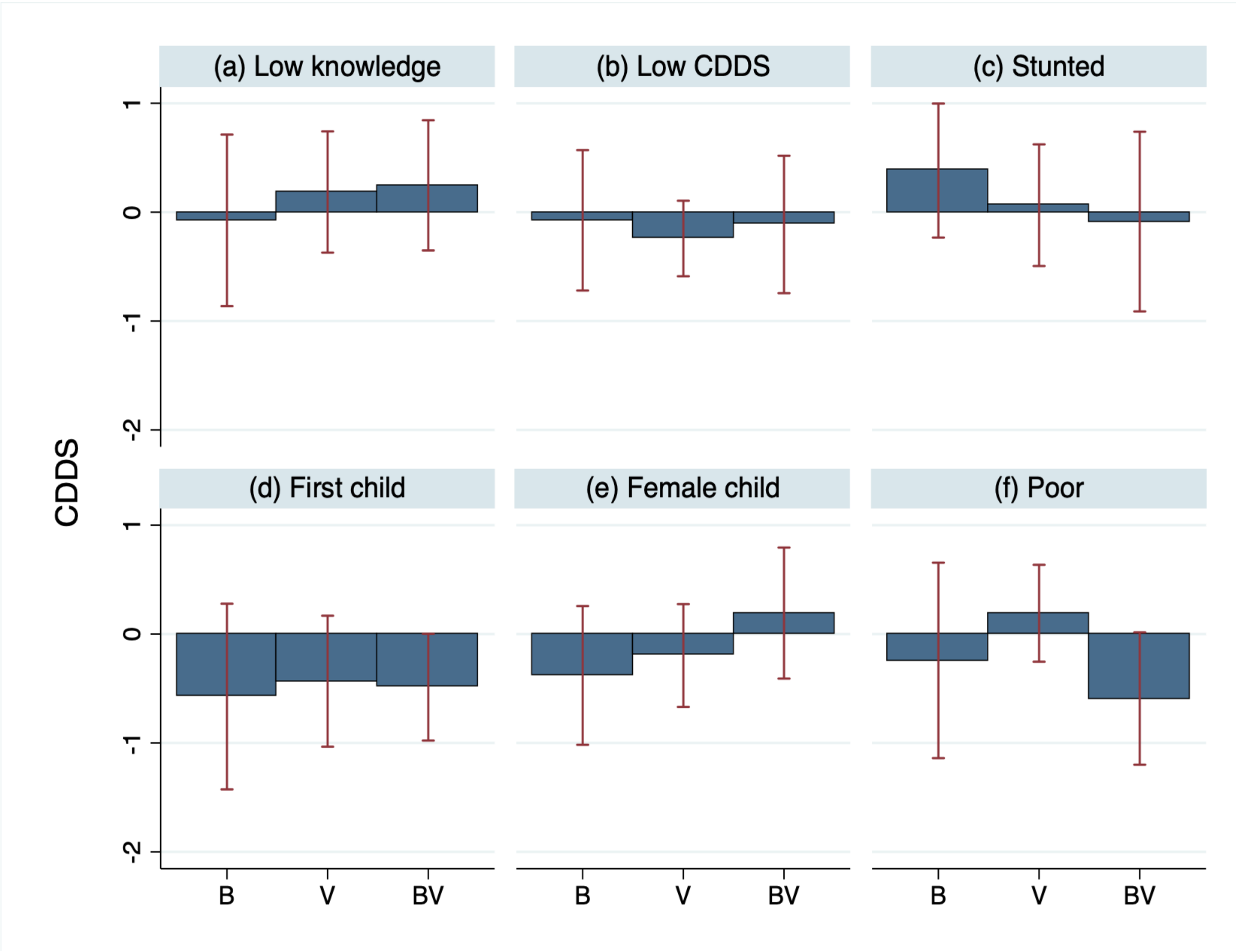
Note: The bar graphs represent mean stunting prevalence at follow-up by study arm conditional on whether stunted at baseline. The red vertical lines indicate 95% confidence intervals. B=BCC, V=Voucher, BV=BCC+Voucher, C=Control.

Figure A7: Heterogeneous Effects on Knowledge



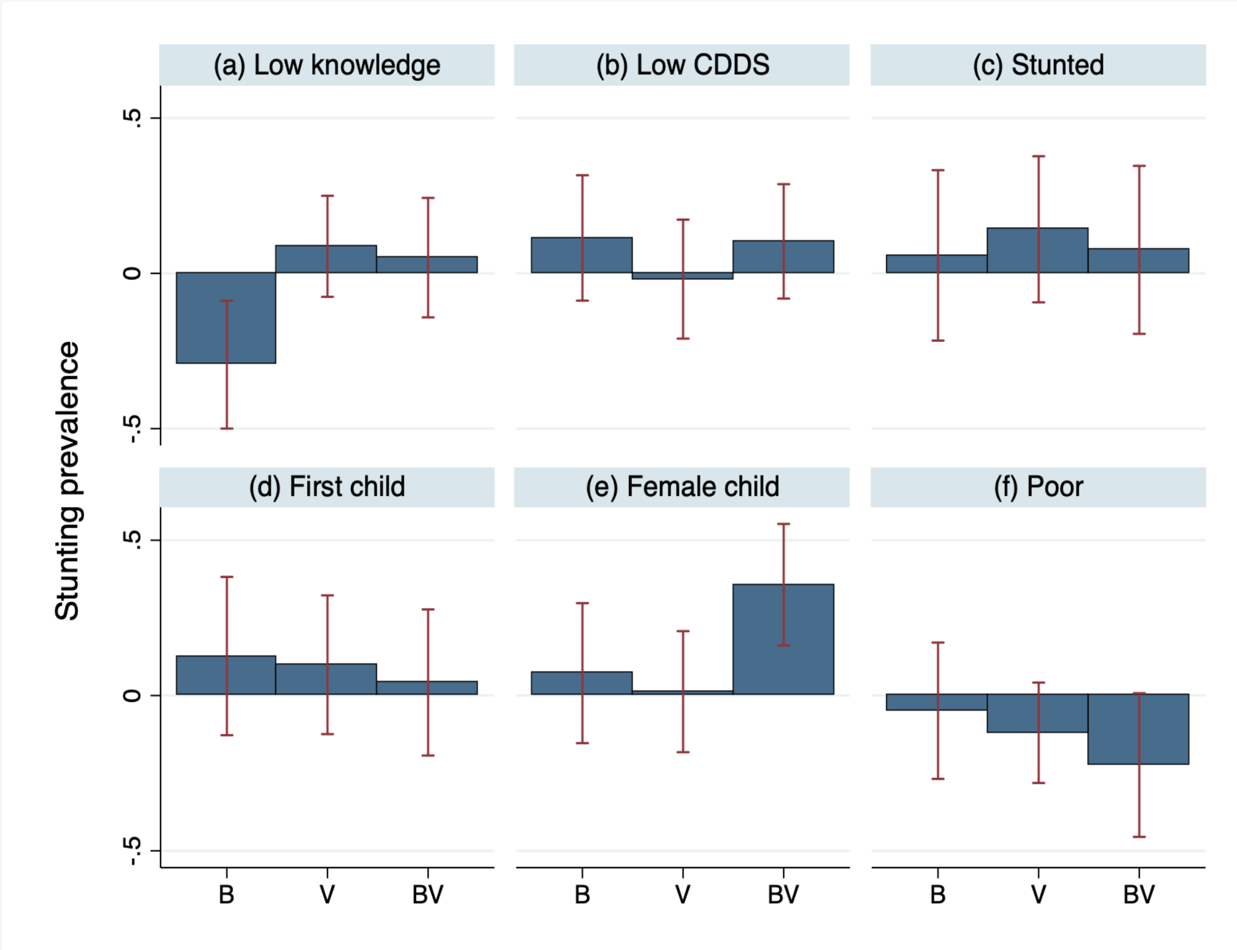
Note: This figure shows heterogeneous treatment effects on mothers' nutritional knowledge score (standardized) by a set of baseline outcomes which include: (a) whether knowledge score lower than the median, (b) whether child dietary diversity score (CDDS) 2 or less food groups, (c) whether child stunted at baseline, (d) whether first child (new mother), (e) whether female child, and (f) whether asset index below the median (poor). The bar graphs represent coefficient estimates of the interaction term between treatment and baseline characteristic of interest. The red vertical lines indicate 95% confidence intervals. B=BCC, V=Voucher, BV=BCC+Voucher.

Figure A8: Heterogeneous Effects on CDDS



Note: This figure shows heterogeneous treatment effects on child dietary diversity score (CDDS) by a set of baseline outcomes which include: (a) whether knowledge score lower than the median, (b) whether child dietary diversity score (CDDS) 2 or less food groups, (c) whether child stunted at baseline, (d) whether first child (new mother), (e) whether female child, and (f) whether asset index below the median (poor). The bar graphs represent coefficient estimates of the interaction term between treatment and baseline characteristic of interest. The red vertical lines indicate 95% confidence intervals. B=BCC, V=Voucher, BV=BCC+Voucher.

Figure A9: Heterogeneous Effects on Stunting Prevalence



Note: This figure shows heterogeneous treatment effects on stunting prevalence by a set of baseline outcomes which include: (a) whether knowledge score lower than the median, (b) whether child dietary diversity score (CDDS) 2 or less food groups, (c) whether child stunted at baseline, (d) whether first child (new mother), (e) whether female child, and (f) whether asset index below the median (poor). The bar graphs represent coefficient estimates of the interaction term between treatment and baseline characteristic of interest. The red vertical lines indicate 95% confidence intervals. B=BCC, V=Voucher, BV=BCC+Voucher.

Table A1: Effects on BCC Attendance and Mother IYCF Knowledge by Topic

	IYCF Topics:					
	Animal source foods	Vitamin A-rich fruits & veg.	Malnutrition & care	Feeding quantity, frequency, thickness	Age of intro-duction	Hygiene
	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Attendance rate by topic						
BCC (B)	0.687***	0.604***	0.729***	0.761***	0.653***	0.953***
	(0.029)	(0.040)	(0.054)	(0.028)	(0.024)	(0.022)
Voucher (V)	-0.009	-0.014	-0.005	-0.000	-0.001	-0.001
	(0.011)	(0.021)	(0.017)	(0.010)	(0.006)	(0.012)
BCC & Voucher (BV)	0.714***	0.657***	0.715***	0.773***	0.777***	0.802***
	(0.024)	(0.043)	(0.026)	(0.017)	(0.019)	(0.034)
Observations	637	637	637	637	637	637
R-squared	0.825	0.731	0.747	0.866	0.819	0.830
P-value: B=BV	0.466	0.329	0.836	0.715	0.000	0.000
Panel B. Knowledge score by topic						
BCC (B)	0.358***	0.385***	0.353***	0.198**	0.312***	0.038
	(0.134)	(0.085)	(0.118)	(0.091)	(0.096)	(0.154)
	[0.033]	[0.001]	[0.011]	[0.036]	[0.004]	[0.800]
	{0.024}	{0.001}	{0.005}	{0.140}	{0.021}	{0.766}
Voucher (V)	0.028	0.096	0.096	0.013	0.012	0.015
	(0.124)	(0.104)	(0.160)	(0.113)	(0.096)	(0.118)
	[0.827]	[0.406]	[0.588]	[0.900]	[0.904]	[0.911]
	{0.860}	{0.466}	{0.459}	{0.930}	{0.931}	{0.900}
BCC & Voucher (BV)	0.282**	0.308***	0.343***	0.256***	0.211**	0.051
	(0.109)	(0.091)	(0.081)	(0.084)	(0.091)	(0.102)
	[0.015]	[0.004]	[0.000]	[0.002]	[0.046]	[0.643]
	{0.058}	{0.020}	{0.003}	{0.091}	{0.132}	{0.644}
Observations	584	584	584	584	584	584
R-squared	0.080	0.074	0.083	0.072	0.108	0.071
P-value: B=V	0.034	0.010	0.166	0.110	0.002	0.890
P-value: B=BV	0.608	0.430	0.937	0.565	0.277	0.944
P-value: V=BV	0.076	0.060	0.137	0.044	0.041	0.796

This table reports results on BCC attendance rate and mothers' IYCF knowledge score (standardized) by IYCF topic. Panel A uses administrative data collected during intervention and compares BCC attendance rates with the control group where the control and the voucher group's attendance rates are set to zero. Panel B uses survey data on mothers' IYCF knowledge collected after intervention completion. All estimations include area dummies, mother's age, whether mother is married, working, able to read, and able to write, mother's years of schooling, eligible child age, household size, number of children, whether female-headed household, household asset index, ethnicity, and religion. Panel B additionally controls for the baseline outcome. Robust standard errors clustered at the unit of randomization, the village level, in parentheses. Wild-cluster bootstrap p-values in square brackets. Randomization inference p-values in curly brackets. The last four rows report p-values from F-tests of coefficient equality between treatment groups. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A2: Effects on Other Child Diet Quality Measures

	Minimum dietary diversity	Minimum meal frequency	Number of times breastfed yesterday	Number of times ate solid or semi-solid food yesterday
	(1)	(2)	(3)	(4)
BCC (B)	0.046	0.071	0.359**	0.126
	(0.053)	(0.074)	(0.172)	(0.219)
	[0.407]	[0.387]	[0.057]	[0.546]
	{0.499}	{0.360}	{0.090}	{0.555}
Voucher (V)	-0.036	0.043	0.249	0.303**
	(0.051)	(0.061)	(0.177)	(0.145)
	[0.516]	[0.478]	[0.188]	[0.055]
	{0.598}	{0.598}	{0.244}	{0.127}
BCC & Voucher (BV)	0.167***	0.146*	0.004	0.495**
	(0.047)	(0.068)	(0.178)	(0.189)
	[0.015]	[0.067]	[0.988]	[0.023]
	{0.021}	{0.079}	{0.985}	{0.026}
Observations	583	440	490	580
R-squared	0.123	0.067	0.146	0.062
Control group mean	0.328	0.565	5.272	2.678
P-value: B=V	0.140	0.712	0.594	0.376
P-value: B=BV	0.038	0.403	0.097	0.142
P-value: V=BV	0.001	0.159	0.196	0.304
P-value: B+V=BV	0.057	0.774	0.023	0.825

This table reports results on minimum dietary diversity, minimum meal frequency, number of times breastfed yesterday, and number of times ate solid or semi-solid food yesterday, collected after intervention completion. All estimations include the baseline outcome, area dummies, mother's age, whether mother is married, working, able to read, and able to write, mother's years of schooling, eligible child age, household size, number of children, whether female-headed household, household asset index, ethnicity, and religion. Robust standard errors clustered at the unit of randomization, the village level, in parentheses. Wild-cluster bootstrap p-values in square brackets. Randomization inference p-values in curly brackets. The last four rows report p-values from F-tests of coefficient equality between treatment groups. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A3: Effects on Hygiene Behavior

	Hygiene score (standardized)
	(1)
BCC (B)	0.056
	(0.051)
	[0.331]
	{0.271}
Voucher (V)	-0.111**
	(0.051)
	[0.051]
	{0.074}
BCC & Voucher (BV)	0.045
	(0.039)
	[0.262]
	{0.312}
Observations	520
R-squared	0.131
Control group mean	-0.071
P-value: B=V	0.013
P-value: B=BV	0.851
P-value: V=BV	0.006
P-value: B+V=BV	0.189

This table reports results on hygiene score which takes a mean of how often the mother washes hands before cooking, washes hands before feeding, washes food before preparing child meal, washes dishes before using to feed child, washes dish with clean water, washes bottle before feeding, and sterilizes bottle (on a scale of 1=Never to 5=Always), collected after intervention completion. All estimations control for the baseline outcome, area dummies, mother's age, whether mother is married, working, able to read, and able to write, mother's years of schooling, eligible child age, household size, number of children, whether female-headed household, household asset index, ethnicity, and religion. Robust standard errors clustered at the unit of randomization, the village level, in parentheses. Wild-cluster bootstrap p-values in square brackets. Randomization inference p-values in curly brackets. The last four rows report p-values from F-tests of coefficient equality between treatment groups. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A4: Effects on Household Food Consumption

	FCS	Whether household ate in the last week:								
		Meat & poultry	Milk & milk prod.	Eggs	Vitamin A-rich fruits & veg.	Nuts & legumes	Other fruits & veg.	Staples	Oils & fats	Sugar & spices
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
BCC (B)	5.446***	0.147**	-0.049	0.005	-0.049	-0.036*	-0.013	0.013*	0.016*	-0.004
	(1.672)	(0.070)	(0.050)	(0.064)	(0.050)	(0.019)	(0.015)	(0.007)	(0.009)	(0.012)
	[0.002]	[0.074]	[0.379]	[0.956]	[0.379]	[0.083]	[0.469]	[0.088]	[0.078]	[0.729]
	{0.009}	{0.036}	{0.061}	{0.947}	{0.455}	{0.330}	{0.125}	{0.174}	{0.280}	{0.597}
Voucher (V)	1.750	0.070	0.020	-0.002	0.020	-0.003	-0.019	-0.006	0.003	-0.007
	(2.154)	(0.067)	(0.056)	(0.064)	(0.056)	(0.027)	(0.011)	(0.016)	(0.010)	(0.011)
	[0.470]	[0.335]	[0.735]	[0.981]	[0.735]	[0.923]	[0.170]	[0.757]	[0.814]	[0.729]
	{0.398}	{0.318}	{0.067}	{0.974}	{0.739}	{0.116}	{0.897}	{0.659}	{0.860}	{0.370}
BCC & Voucher	5.658***	0.149**	0.187***	0.213***	0.187***	0.011	-0.014	0.005	0.003	0.003
(BV)	(1.632)	(0.060)	(0.059)	(0.050)	(0.059)	(0.026)	(0.011)	(0.011)	(0.013)	(0.004)
	[0.007]	[0.030]	[0.002]	[0.002]	[0.002]	[0.696]	[0.222]	[0.674]	[0.815]	[0.411]
	{0.009}	{0.051}	{0.068}	{0.005}	{0.010}	{0.217}	{0.635}	{0.644}	{0.834}	{0.334}
Observations	583	583	583	583	583	583	583	583	583	583
R-squared	0.218	0.201	0.245	0.203	0.245	0.061	0.064	0.055	0.047	0.051
Control group mean	53.425	0.360	0.234	0.345	0.402	0.061	0.992	0.985	0.985	1.000
P-value: B=V	0.107	0.377	0.255	0.929	0.255	0.218	0.714	0.197	0.151	0.865
P-value: B=BV	0.906	0.971	0.000	0.002	0.000	0.094	0.932	0.421	0.249	0.467
P-value: V=BV	0.096	0.300	0.007	0.001	0.007	0.689	0.737	0.519	0.965	0.377
P-value: B+V=BV	0.594	0.494	0.007	0.018	0.007	0.222	0.430	0.887	0.254	0.397

This table reports results on household food consumption score (FCS) and household food consumption by food group, collected after intervention completion. Outcomes in Columns 2-10 indicate whether the household ate any food item from the food group. All estimations control for the baseline outcome, area dummies, mother's age, whether mother is married, working, able to read, and able to write, mother's years of schooling, eligible child age, household size, number of children, whether female-headed household, household asset index, ethnicity, and religion. Robust standard errors clustered at the unit of randomization, the village level, in parentheses. Wild-cluster bootstrap p-values in square brackets. Randomization inference p-values in curly brackets. The last four rows report p-values from F-tests of coefficient equality between treatment groups. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Table A5: Effects on Household Expenditures (After Intervention Completion)

	Total food expenditure	Total non-food expenditure	Amount spent per capita in the last week: Meat and fish	Milk and milk products	Eggs	Vitamin A-rich fruits & veg.	Other fruits & veg.	Nuts and legumes	Starchy staples	Oils and fats	Sugars, drinks, spices
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
BCC (B)	13.34	-4.623	9.662**	-0.858	-0.209	0.192	1.863*	3.473***	1.056	-0.302	-1.378
	(10.75)	(3.273)	(4.212)	(1.226)	(0.257)	(0.253)	(1.037)	(1.259)	(6.167)	(1.153)	(2.707)
	[0.297]	[0.193]	[0.044]	[0.537]	[0.410]	[0.512]	[0.115]	[0.026]	[0.885]	[0.842]	[0.620]
	{0.253}	{0.249}	{0.023}	{0.548}	{0.538}	{0.782}	{0.029}	{0.060}	{0.866}	{0.770}	{0.665}
Voucher (V)	13.68	4.559	12.67**	0.176	-0.287	-0.207	0.148	0.171	-2.824	1.187	2.231
	(12.26)	(3.511)	(5.152)	(1.329)	(0.336)	(0.223)	(0.618)	(1.106)	(7.011)	(0.955)	(1.672)
	[0.307]	[0.203]	[0.024]	[0.931]	[0.655]	[0.368]	[0.818]	[0.895]	[0.695]	[0.479]	[0.343]
	{0.293}	{0.269}	{0.005}	{0.910}	{0.515}	{0.781}	{0.857}	{0.917}	{0.715}	{0.321}	{0.462}
BCC & Voucher (BV)	12.01	9.983*	7.494**	1.418	0.580*	0.967***	0.930	0.325	-3.931	0.098	3.487**
	(10.52)	(5.215)	(3.652)	(1.329)	(0.336)	(0.271)	(0.618)	(1.106)	(7.011)	(0.955)	(1.672)
	[0.307]	[0.190]	[0.085]	[0.313]	[0.135]	[0.007]	[0.144]	[0.777]	[0.642]	[0.933]	[0.042]
	{0.329}	{0.053}	{0.099}	{0.346}	{0.122}	{0.528}	{0.226}	{0.874}	{0.620}	{0.933}	{0.224}
Observations	583	583	583	583	583	583	583	583	583	583	583
R-squared	0.228	0.162	0.100	0.111	0.102	0.155	0.250	0.100	0.170	0.059	0.125
Control group mean	81.008	31.451	13.003	4.303	0.960	0.769	6.592	3.001	30.824	5.797	15.759
P-value: B=V	0.980	0.023	0.618	0.608	0.893	0.147	0.101	0.032	0.568	0.393	0.230
P-value: B=BV	0.915	0.009	0.636	0.119	0.020	0.011	0.413	0.035	0.487	0.773	0.075
P-value: V=BV	0.889	0.237	0.345	0.537	0.131	0.000	0.338	0.910	0.870	0.494	0.599
P-value: B+V=BV	0.386	0.075	0.030	0.360	0.093	0.010	0.447	0.071	0.815	0.696	0.485

This table reports results on weekly household food and non-food expenditure in total and by food group, collected after intervention completion. Each outcome indicates the amount spent by household in the last week per capita in Ethiopian Birr. All estimations control for the baseline outcome, area dummies, mother's age, whether mother is married, working, able to read, and able to write, mother's years of schooling, eligible child age, household size, number of children, whether female-headed household, household asset index, ethnicity, and religion. Robust standard errors clustered at the unit of randomization, the village level, in parentheses. Wild-cluster bootstrap p-values in square brackets. Randomization inference p-values in curly brackets. The last four rows report p-values from F-tests of coefficient equality between treatment groups. *** $p<0.01$, ** $p<0.05$, * $p<0.1$.

Appendix B Proofs

Proof of Proposition

The optimization problem that the household solves is

$$\max_{X,C} U(A,H) = A(X) + H(C,K)$$
$$s.t.: \; X + pC \leq Y$$

where $U(.,.)$ captures the utility from adult consumption utility (A) and child health (H). X is adult consumption, C is child nutritional input, K is nutritional knowledge, p is the price of child nutrition input relative to adult consumption, and Y is income. The function $A(.)$ represents the adult consumption utility function and $H(.,.)$ represents the child health production function. We assume that $A(X)$ is increasing in X and concave, and $H(C,K)$ is increasing in C and K.

Case 1: General Child Health Production Function

Assume that the adult consumption utility and the child health production function are Cobb-Douglas: $A(X) = \gamma \ln X$ and $H(C,K) = \alpha \ln C + \beta \ln K$ where $\alpha, \beta, \gamma > 0$ and $\alpha + \beta < 1$. The optimization problem is:

$$\max_{X,C} \gamma \ln X + \alpha \ln C + \beta \ln K$$
$$s.t.: \; X + pC \leq Y$$

where K, p, and Y are given. As the objective function is increasing in each argument, the budget constraint will be binding at the optimum. We use the budget constraint to solve for X and substitute in the objective function to obtain:

$$\max_{C} \ \gamma \ln (Y - pC) + \alpha \ln C + \beta \ln K$$

The first-order condition is:

$$\frac{-\gamma p}{Y - pC} + \frac{\alpha}{C} = 0 \tag{B1}$$

Rearranging B1 to solve for C, we have:

$$C^{*} = \frac{\alpha Y}{p(\alpha + \gamma)} \tag{B2}$$

To examine changes in H given changes in Y and K, we plug equation B2 into the health production function:

$$H^{*} = \alpha \ln \left(\frac{\alpha Y}{p(\alpha + \gamma)} \right) + \beta \ln K$$

Taking partial derivates of H^{*} with respect to Y and K:

$$\frac{\partial H}{\partial Y} = \frac{\alpha}{Y} > 0 \tag{B3}$$

$$\frac{\partial H}{\partial K} = \frac{\beta}{K} > 0 \tag{B4}$$

which show that marginal child health returns to income and knowledge are both positive. It follows that $H^{0} < H^{V} \lesseqgtr H^{B} < H^{BV}$, where H^{0}, H^{V}, H^{B}, and H^{BV} denote child health status given no change (control), given increase in income ($Voucher$), given increase in knowledge (BCC), and given increase in both ($BCC + Voucher$), respectively.

Case 2: (Near) Perfect Complements Child Health Production Function

To illustrate a simplified case in which the marginal returns to an input is constrained by the other input, we assume a perfect complement relationship between nutritional input and knowledge. This is represented by $H(C, K) = min\{\alpha C, \beta K\}$, with $\alpha, \beta > 0$. We can therefore rewrite the optimization problem as:

$$\max_{X,C} \; A(X) + min\{\alpha C, \beta K\}$$
$$s.t.: \; X + pC \leq Y$$

where K, p, and Y are given. The optimal bundle for perfect complements satisfy $\alpha C = \beta K$, i.e., optimal bundles are located at the kinks of the indifference curves. This means that starting at one of the kinks, using more of X or more of K does not increase child health. As K is exogenous, the constraint for $H(C, K)$ is $C = \frac{Y-X}{p}$ which is obtained by rearranging the budget constraint, represented by the green vertical line in Figure B1. Using the intersection of the line $\alpha C = \beta K$ with the budget constraint, we can find the solution to the optimization problem as follows:

$$C^* = \frac{\beta}{\alpha} K \tag{B5}$$
$$X^* = Y - \frac{\beta}{\alpha} K p \tag{B6}$$

Based on this set-up, we will examine the following three scenarios: 1) changes in child health given increase in income, 2) changes in child health given increase in knowledge, and 3) changes in child health given increase in both income and knowledge. We show the three scenarios graphically, as the kinked child health function cannot be differentiated. C_0, K_0, X_0, and Y_0 denote control group values of child nutritional input, nutritional knowledge, adult consumption, and income, respectively.

Figure B2 illustrates the first scenario. Given increase in income, while it is possible to increase C, it is not utility-maximizing to do so as it does not result in any increase in child health given K_0. This is represented by $\frac{\partial C}{\partial Y} = 0$. Thus, given increase in income with knowledge remaining constant, the child nutritional input remains the same at $C_0 = \frac{\beta}{\alpha} K_0$ and child health remains unchanged: $H^V = min\{\alpha C_0, \beta K_0\} = H^0$ (Figure B2).

Given increase in knowledge, the changes in the consumption bundle are such that $\frac{\partial C}{\partial K} = \frac{\beta}{\alpha} > 0$ and $\frac{\partial X}{\partial K} = -\frac{\beta}{\alpha} p < 0$. Thus, the increase in K leads to increase in C and decrease in X consumption. In the case of unconstrained households such that $Y \geq X^* + pC^*$, they can afford C^*. However, in the case of constrained households, $Y < X^* + pC^*$, they cannot afford C^*—i.e., they do not have enough income to practice their knowledge. Hence, the increase in C is limited, which in turn constrains knowledge (Figure B3). To reflect the study setting, we assume that households are constrained by income. This results in some improvements in child health but not to the full extent of the knowledge increase: $H^B = min\{C_1, K_1\} \geq H^0$ where $C_1 < \frac{\beta}{\alpha} K_1$ (Figure B3).[1]

Lastly, given increase in both income and knowledge, households are now fully able to afford the increase in knowledge, leading to further increase in C (Figure B4). Reflecting the study setting, we assume that amount of the income increase (voucher transfers) is sufficient for purchasing optimal child nutritional inputs: $Y \geq X^* + pC^*$. This leads to further improvements in child health: $H^{BV} = min\{C_1, K_1\} > H^B \geq H^0$ where $C_1 = \frac{\beta}{\alpha} K_1$ (Figure B4). In summary, we obtain that $H^0 = H^V \leq H^B < H^{BV}$.

In conclusion, the above two cases of child health production functions that assume different relationships between C and K allow us to establish the following proposition:

Proposition. If C and K are imperfect complements, then $H^0 < H^V \lesseqgtr H^B < H^{BV}$.

[1] $H^V = H^B$ would hold in an extreme case of income constraint, $Y \leq \bar{X} + p\bar{C}$, where $\bar{X}$ and $\bar{C}$ represent subsistence level household consumption and child nutritional inputs.

However, if C and K are (near) perfect complements, then $H^0 \backsimeq H^V \leq H^B < H^{BV}$.

Figure B1. Child Health Function (No change)

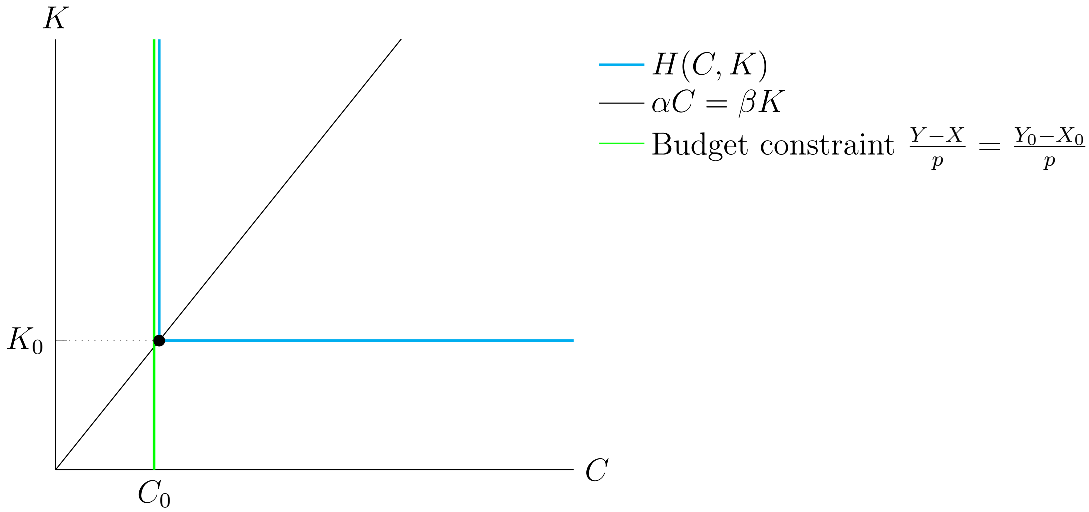


Figure B2. Voucher ($Y_0 \rightarrow$Y$_1$)

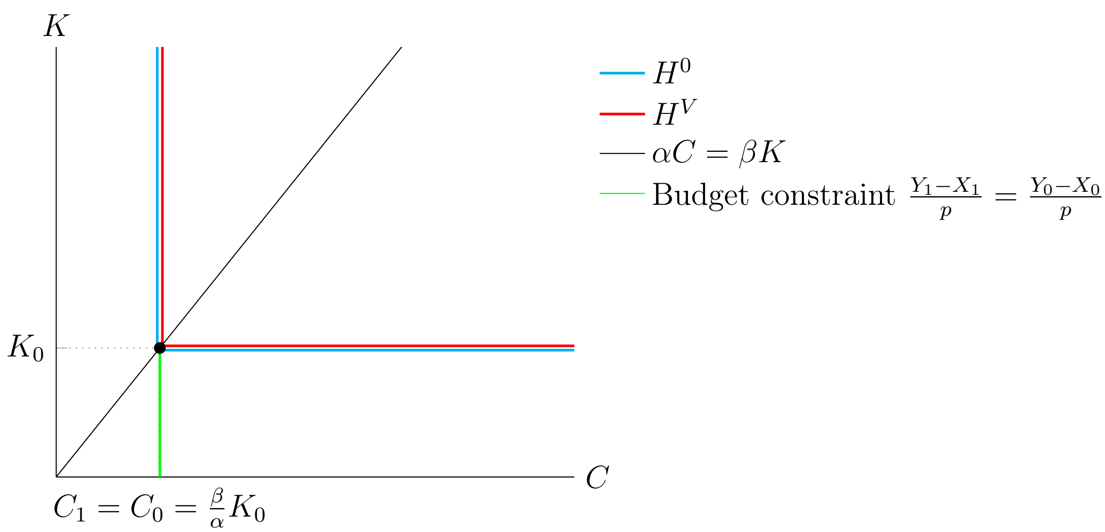


Figure B3. BCC ($K_0 \rightarrow$K$_1$)

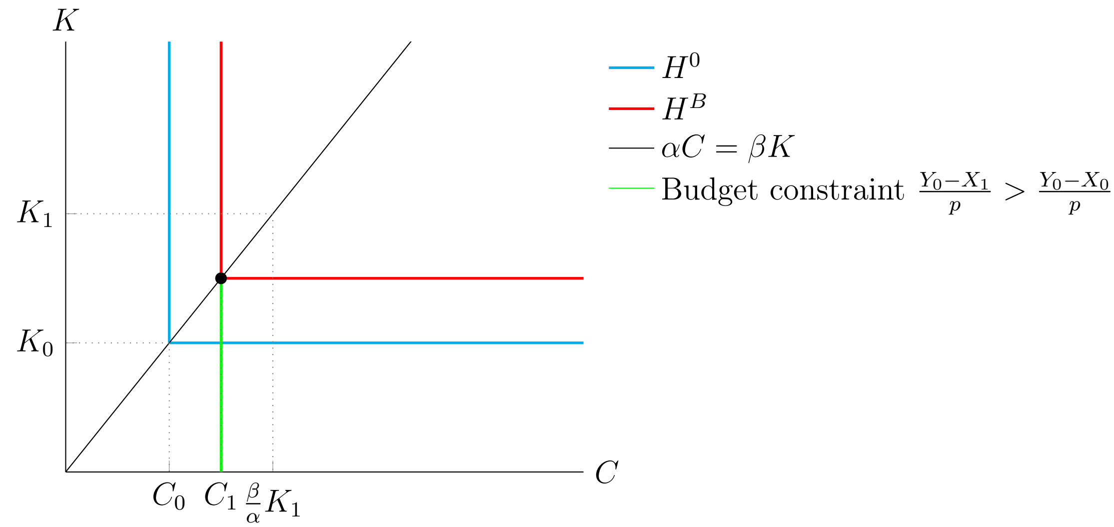
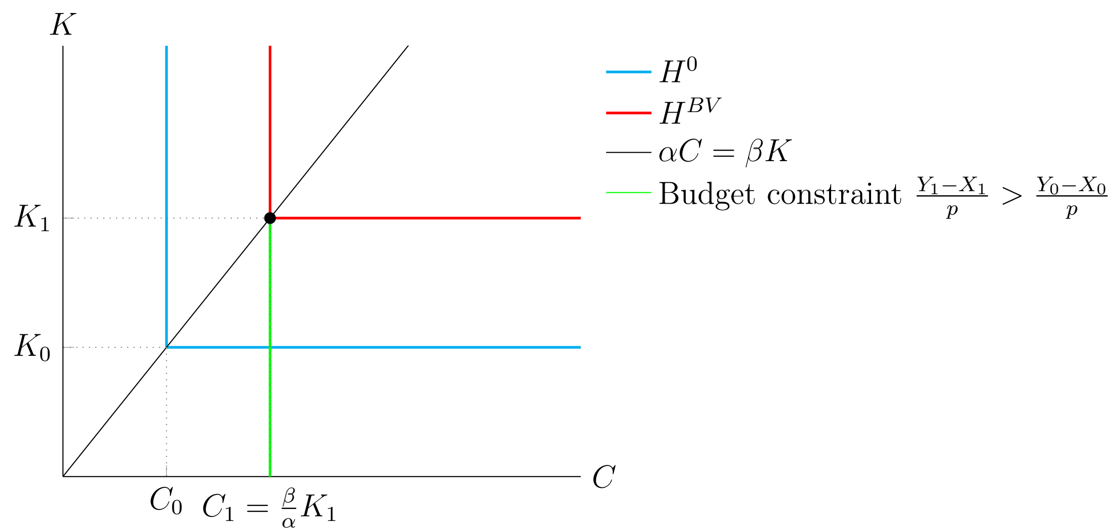


Figure B4. BCC & Vouchers ($Y_0 \rightarrow$Y$_1$ & $K_0 \rightarrow$K$_1$)



Appendix C Mother IYCF BCC Curriculum

Week	Contents	Week	Contents
1	Introduction	9	A: Frequency & amount of complementary food B: Eating schedule & discussion
2	Dietary diversity and weekly diet schedule	10	Recipe and cooking demonstration
3	When to start complementary feeding	11	Responsive feeding
4	Thickness & consistency of complementary food	12	Feeding during illness
5	Role play & discussion	13	Role play & discussion
6	Food variety-iron, proteins from meat	14	Hygienic preparation & storage of food
7	A: Enrichment of complementary food B: Household food processing strategy	15	Group discussion & review
8	Role play & discussion	16	Testimonials & ceremony