The Journal of Nutrition. First published ahead of print April 22, 2015 as doi: 10.3945/jn.114.203539.



# A 2-Year Integrated Agriculture and Nutrition and Health Behavior Change Communication Program Targeted to Women in Burkina Faso Reduces Anemia, Wasting, and Diarrhea in Children 3–12.9 Months of Age at Baseline: A Cluster-Randomized Controlled Trial[1–3]

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## Abstract

**Background:** Among young children in Burkina Faso, anemia and chronic and acute undernutrition are widespread.

**Objective:** This study assesses the impact of Helen Keller International's (HKI) 2-y integrated agriculture [homestead food production (HFP)] and nutrition and health behavior change communication (BCC) program, targeted to women, on children's (3–12.9 mo old at baseline) anthropometry (stunting, wasting, and underweight), mean hemoglobin (Hb), anemia (Hb < 11 g/dL), and diarrhea prevalence.

**Methods:** We used a cluster-randomized controlled trial, with 55 villages randomly assigned to a control group (*n* = 25) or 1 of 2 treatment groups (*n* = 15 each), which differed by who delivered the BCC messages [older women leaders or health committee (HC) members]. We used difference-in-difference (DID) estimates to assess impacts on child outcomes.

**Results:** We found marginally significant ($P < 0.10$) impacts on Hb (DID: 0.51 g/dL; $P = 0.07$) and wasting [DID: −8.8 percentage point (pp); $P = 0.08$] and statistically significant ($P < 0.05$) impacts on diarrhea (−15.9 pp; $P = 0.00$) in HC compared with control villages among children aged 3–12.9 mo and larger impacts for anemia (DID: −14.6 pp; $P = 0.03$) and mean Hb (DID: 0.74 g/dL; $P = 0.03$) among younger children (aged 3–5.9 mo). However, we found no significant impacts on stunting or underweight prevalence. Plausibility was supported by greater improvements in women's agricultural production and maternal infant and young child feeding and care knowledge and practices in HC compared with control villages.

**Conclusions:** HKI's 2-y integrated HFP+BCC program (HC group) significantly improved several child outcomes, including wasting (marginal), diarrhea, Hb, and anemia, especially among the youngest children. This is the first cluster-randomized controlled trial of an HFP program that documents statistically significant positive effects on these child nutrition outcomes. This trial was registered at clinicaltrials.gov as NCT01825226. *J Nutr* doi: 10.3945/jn.114.203539.

**Keywords:** children, anemia, undernutrition, homestead food production programs, Africa

## Introduction

Anemia [hemoglobin concentration (Hb)[7] < 11.0 g/dL] and wasting [weight-for-height *z* score (WHZ) < −2 SDs] are 2 of the most severe nutritional problems that face Burkinabé children. Anemia is nearly universal and, at 92% among children younger than 5 y of age, is the highest in the world (1). Among 21 countries in sub-Saharan Africa, Burkina Faso also has the highest prevalence of moderate-to-severe anemia (45% among children

[1] Supported by the US Agency for International Development, Office of US Foreign Disaster Assistance (USAID/OFDA) through Helen Keller International (HKI); the Gender, Agriculture and Assets Project (GAAP); the CGIAR Research Program on Agriculture for Nutrition and Health (A4NH) led by the International Food Policy Research Institute (IFPRI). AD is supported by the National Institute of Food and Agriculture (USDA).
[2] Author disclosures: DK Olney, MT Ruel, and A Dillon, no conflicts of interest. A Pedehombga is an employee of Helen Keller International.

[3] Supplemental Table 1 is available from the ''Online Supporting Material'' link in the online posting of the article and from the same link in the online table of contents at http://jn.nutrition.org.
[7] Abbreviations used: BCC, behavior change communication; DID, difference-in-difference; E-HFP, enhanced-homestead food production; HAZ, height-for-age *z* score; Hb, hemoglobin concentration; HC, health committee; HFP, homestead food production; HKI, Helen Keller International; IYCF, infant and young child feeding; OWL, older woman leader; pp, percentage point; WAZ, weight-for-age *z* score; WHZ, weight-for-height *z* score.
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Manuscript received September 5, 2014. Initial review completed October 14, 2014. Revision accepted March 23, 2015.
doi: 10.3945/jn.114.203539.

6–23 mo of age) (2) and the highest (among 22 sub-Saharan countries) prevalence of wasting at 14% (3). Stunting [height-for-age $z$ score (HAZ) < −2 SDs] and underweight [weight-for-age $z$ score (WAZ) < −2 SDs] (both ~30%) are also prevalent among children <5 y of age in Burkina Faso (2).

Undernutrition and anemia share several risk factors, including illness and energy and micronutrient deficiencies. Lack of access to high-quality foods, especially tied to seasonal variations and water shortages (4, 5), and suboptimal infant and young child feeding (IYCF) and hygiene and sanitation practices (6–8) likely contribute to energy and micronutrient deficiencies and increased exposure to pathogens that cause diarrhea and other infections. According to the 2010 Burkina Faso Demographic and Health Surveys, in the 24 h before the interview, <25% of children <6 mo of age were exclusively breastfed, only 46% of children 6–8 mo of age received solid or semisolid food, and only 5% of breastfed children 6–23 mo of age were fed ≥4 food groups (2). In addition, limited access to and use of preventive and curative measures for diarrhea and malaria [prevalence: 15% and 66% among children <5 y of age, respectively (2)] may further exacerbate the effects of these diseases on children's growth (9). Zinc deficiency, for which the Burkinabé population is at high risk, is also linked to stunting (8). Likewise, illness and micronutrient deficiencies play a large role in the cause of anemia. Although iron deficiency is the primary cause of anemia, other micronutrient deficiencies (i.e., vitamin A, vitamin B-12, folate, riboflavin, and copper) and malaria are likely important causes of anemia in this population (1, 10).

Nutrition-specific interventions to improve growth and reduce anemia in Burkina Faso are needed, but the recent *Lancet* series on maternal and child nutrition also emphasizes the need to simultaneously address the underlying determinants of malnutrition through multi-sectorial nutrition-sensitive programs to accelerate progress in improving nutrition during the first 1000 d (from pregnancy to the child's second birthday) (11). Agriculture is one sector that has great potential to contribute to improving nutrition. However, current evidence of agriculture's impact on child nutrition is limited, because of weaknesses in program targeting, design, implementation, and, equally importantly, poor evaluation designs. With the exception of 2 cluster-randomized trials that showed the impact of biofortified orange sweet potato on child vitamin A intake and status (12, 13), the small body of evidence on the nutritional impact of agriculture programs comes mostly from underpowered and poorly designed evaluation studies (11, 14–16).

This study addresses several weaknesses in this existing body of evidence. It uses a cluster-randomized design to evaluate the impact of a carefully designed enhanced-homestead food production (E-HFP) program implemented by an experienced nongovernmental organization [Helen Keller International (HKI)] on child anthropometry, Hb, anemia, and diarrhea (17). The program targets households with women and children in the first 1000 d and integrates agriculture production activities with a strong nutrition and health behavior change communication (BCC) strategy with the explicit goal of improving children's nutritional outcomes. The study also collected data on intermediary outcomes along the hypothesized program impact pathways (from agriculture production to consumption of nutrient-rich foods and from maternal acquisition of knowledge to adoption of optimal IYCF and health practices) to establish plausibility of the findings.

## Methods

### Program description

HKI's E-HFP program implemented in the province of Gourma in Burkina Faso consisted of 2 primary components: agriculture production activities and a nutrition and health BCC strategy. The agriculture production activities included input distribution (e.g., seeds, saplings, chicks, and small gardening tools) and agriculture training provided by 4 female village farm leaders at demonstration farms. After receipt of inputs and training, program beneficiaries started their own HFP activities, primarily production of micronutrient-rich fruits and vegetables and eggs and chicks. The BCC strategy was designed with the essential nutrition actions framework that focuses on 7 practices as follows: *1*) women's nutrition, *2*) anemia prevention and control (e.g., intake of iron-rich foods and use of bed nets to prevent malaria), *3*) iodine intake, *4*) prevention of vitamin A deficiency, *5*) breastfeeding practices, *6*) complementary feeding practices, and *7*) nutritional care for sick and severely malnourished children (18). Participating women received home visits twice a month from either an older woman leader (OWL) or a health committee (HC) member during which they learned about the optimal practices and discussed successes and challenges related to adoption of these practices. These 2 types of actors were selected because the effectiveness of the BCC strategy in improving knowledge and eliciting behavior change may vary by the type of actor delivering the messages. On the one hand, HC members are often used to deliver health and nutrition interventions in rural villages and can facilitate direct links with health services; OWLs, on the other hand, may be more influential in changing IYCF and care practices because they are often the main providers of prenatal and postnatal counseling and child delivery care in rural areas (19). All program components were fully implemented within 6 mo of the baseline survey conclusion.

### Study design and participants

We used a cluster-randomized controlled trial design whereby 55 villages in 4 departments in Gourma province were randomly assigned to 3 groups as follows: *1*) control group that received no interventions from HKI (25 control villages), *2*) treatment group that received the agricultural production intervention with the BCC strategy implemented by OWLs (15 OWL villages), and *3*) treatment group that received the same agricultural production with the BCC intervention implemented by HC members (15 HC villages). Randomization was stratified by department and village size. Villages were selected for inclusion if they were located in the 4 selected departments, had access to water in the dry season to enable participation in the agricultural intervention, and met the population size criteria (≤4000 inhabitants). Of the 181 villages included in the census, only 57 met the population criteria. From these villages, 55 were randomly selected to participate in the program and evaluation. Of these 55, only 40 had an operational dry season water source. The 15 villages that did not have this type of water source received additional support from the program to rehabilitate their primary dry season pump or well.

Within the selected villages ($n$ = 55) all women with children 3–12.9 mo of age at baseline were invited to participate in the study. Trained fieldworkers explained the study to eligible households, and informed consent was obtained from either the household head or the mother of the selected child. We used a longitudinal design and followed the same households, mothers, and children over the 2-y program implementation period. The baseline study was conducted between February and May 2010 (when children were 3–12.9 mo of age), and the end line survey was conducted between February and June 2012 (when children were 24–39.9 mo of age). The protocol was approved by the Ministry of Health of Burkina Faso and the institutional review boards of the International Food Policy Research Institute and Michigan State University.

### Sample size calculations

Sample size calculations were conducted for a 2-level randomized controlled trial by using the Optimal Design Plus Empirical Evidence software version 3.0 (HLM software). The study was restricted to 55 villages that met minimum program eligibility criteria in the 4 departments because of logistics and cost. We estimated a sample size of 30 children per cluster with statistical significance of 0.05, power of 0.80, and an intracluster correlation of 0.02. This sample size provided the ability to detect minimum differences between treatment arms of a change of 0.25 in mean HAZ and WHZ and a 0.3 g/dL change in Hb. The sample also permitted the estimation of changes of 10 percentage points (pp) in the prevalence of wasting, anemia, and diarrhea and 15 pp in stunting. Consistent with reviews of the literature (15), larger program effects on knowledge were expected compared with effects on anthropometric outcomes and thus would require a smaller sample size to detect differences between groups than for the anthropometric outcomes.

### Data collection and measures

*Household surveys.* Data were collected at baseline and end line on household demographic and socioeconomic characteristics, gender-disaggregated asset ownership and value (head of household was asked how many assets of each type were held by men and women in the household and asked to estimate the present value of each asset if sold), agricultural production (20), household dietary diversity (21), health and nutrition knowledge (maternal recall), and IYCF practices [maternal recall and constructed according to the WHO indicators (22)].

*Clinical assessments.* To assess anemia, capillary blood from a finger prick sample was used immediately to measure Hb (Hemocue, AB). Anemia was defined as Hb < 11.0 g/dL and severe anemia as Hb < 7.0 g/dL. For anthropometric measures, trained staff measured weight with the use of an electronic scale whereby weight (to the nearest 100 g) was first taken for mother and child and secondly for the mother alone. The difference was the child's weight. Recumbent length of children <2 y of age and standing height of children >2 y of age was measured to the nearest 0.1 cm with the use of a wooden length board (Shorr Productions). HAZ, WAZ, and WHZ values were calculated with the 2006 WHO growth reference (23). Stunting was defined as length-for-age $z$ score or HAZ < −2 SDs, wasting as WHZ < −2 SDs, and underweight as WAZ < −2 SDs. Diarrhea (defined as watery stool) in the past week was measured by maternal recall.

### Statistical analysis

Statistical analysis was performed with STATA version 12 (StataCorp). A 2-step approach was used to address sample attribution. First, differences between non-attrited and attrited households and children in baseline measures of household descriptives and key outcome variables were examined with regression analysis that adjusted for clustering. Differences were considered statistically significant if $P < 0.05$. Second, attrition weights were estimated and used to re-weight the sample descriptive statistics and impact estimates to account for the probability of a household or child to attrite given their observable characteristics (24). For the sample included in these analyses, balance tests for household descriptives and key outcome variables at baseline were conducted across the 3 treatment groups (control, HC, and OWL) and were considered to be statistically significantly different and not balanced across the 3 groups if $P < 0.05$.

To assess program impacts on anthropometry, Hb, anemia, diarrhea, agriculture production, household dietary diversity, maternal knowledge, and IYCF practices we used difference-in-difference (DID) estimates derived from linear regression analysis. These estimates examined the change in the program indicator variable between the baseline and end line survey; coefficients for the HC and OWL villages were estimated as the difference in the mean change between the HC or OWL villages relative to the control group. For impact analyses only households or individuals with data for a given indicator at both time points were included. Models for estimating impacts on anemia, Hb, and diarrhea controlled for child's sex and age and maternal age; models for estimating impacts on child anthropometry also controlled for maternal height. The SEs of these regressions were adjusted for clustering at the village level and for attrition. Program impacts were considered statistically significant at $P < 0.05$ and marginally statistically significant at $P < 0.10$. The trial was registered with clinicaltrials.gov as NCT01825226.

## Results

*Trial profile and attrition.* In the 55 villages, 1767 households participated in the baseline survey, and of these 1481 participated in the end line survey (**Figure 1**). Only 1 household visited refused to participate in the baseline survey, and all households invited to participate in the program accepted. At end line 1 cluster (village) in the HC group had withdrawn from the program and study. There was a statistically significantly greater loss to follow-up among households and children in the control villages than in the treatment villages (6 and 7 pp, respectively; $P < 0.01$ for both); differences between OWL and HC villages were not statistically significant. The greater retention in the treatment villages was likely because of the on-going program activities in those villages. Attrited compared with non-attrited households were more likely to have fewer household members and children <6 y of age, be female-headed, and have a mother with some formal schooling. No differences were found in housing construction materials, head of household education, or child characteristics between attrited and non-attrited households (data not shown).

*Baseline characteristics.* Households included in the study had an average of between 7 and 8 members and were primarily headed by men (**Table 1**). Formal education was rare for both household heads and children's mothers. Most houses had straw roofs and a little less than one-half had dirt floors. Approximately one-half of the children were boys, and average age at baseline was 7.26 mo. Anemia was nearly universal (88.9%), and the mean Hb was 8.90 g/dL. Undernutrition was common, with 30.7% of the children stunted, 37.9% underweight, and 27.5% wasted. No statistically significant differences were found across the treatment groups for any of the baseline household, maternal, or child characteristics, with the exception of diarrhea prevalence, which was lowest in the control group.

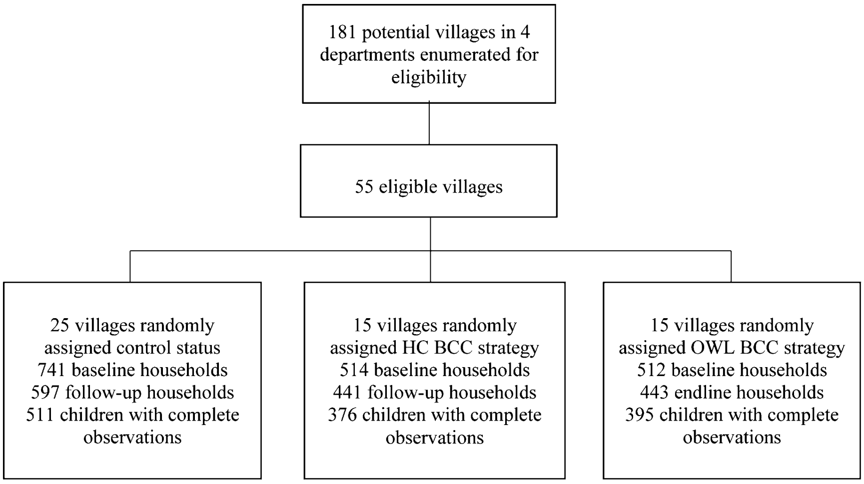


**FIGURE 1** Trial profile. BCC, behavior change communications; HC, health committee; OWL, older woman leader.

**TABLE 1** Unadjusted mean baseline key characteristics of households, mothers, and children included in the study sample among those living in control, OWL, and HC villages[1]

| Variable | All | Control | OWL | HC | P |
|---|---|---|---|---|---|
| HH, N | 1481 | 597 | 443 | 441 | |
| HH size (residents present at least 6 mo) | 7.72 ± 3.69 | 8.02 ± 3.82 | 7.78 ± 3.64 | 7.24 ± 3.52 | 0.33 |
| Children (<6 y of age) per HH, n | 2.63 ± 1.46 | 2.73 ± 1.53 | 2.62 ± 1.36 | 2.52 ± 1.48 | 0.49 |
| Polygamous HH, n (%) | 575 (38.8) | 249 (41.7) | 179 (40.4) | 147 (33.3) | 0.33 |
| Polygamous HH with >1 wife in the survey, n (%) | 90 (6.1) | 38 (6.4) | 25 (5.6) | 27 (6.1) | 0.85 |
| Female-headed HH, n (%) | 99 (6.7) | 39 (6.5) | 29 (6.6) | 31 (7.1) | 0.96 |
| Dirt floor in primary house, n (%) | 617 (41.7) | 213 (35.7) | 190 (42.9) | 214 (48.5) | 0.07 |
| Roofing material is straw mat in primary house, n (%) | 885 (59.8) | 360 (60.3) | 273 (61.6) | 252 (57.1) | 0.70 |
| HH head had any formal education, n (%) | 148 (10.2) | 57 (9.8) | 49 (11.3) | 42 (9.9) | 0.89 |
| Mother had any formal education, n (%) | 96 (6.6) | 39 (6.6) | 26 (5.9) | 31 (7.1) | 0.85 |
| Children, N | 1452 | 577 | 443 | 432 | |
| Child's sex, n (% boys) | 727 (50.1) | 292 (50.6) | 217 (49) | 218 (50.5) | 0.79 |
| Child's age (mo) | 7.26 ± 2.65 | 7.40 ± 2.64 | 7.14 ± 2.60 | 7.21 ± 2.71 | 0.26 |

[1] Values are means ± SDs or n (%). HC, health committee; HH, household; OWL, older woman leader.

***Impacts on child Hb, anemia, anthropometry, and diarrhea.*** The E-HFP program had a marginally statistically significant impact on improving mean Hb among children 3–12.9 mo of age at baseline living in HC villages compared with control villages (DID: 0.51 g/dL; $P$ = 0.06) (**Table 2**). This difference was larger and statistically significant among children 3–5.9 mo of age

**TABLE 2** Unadjusted mean Hb, HAZ, WAZ, and WHZ and prevalence of anemia, severe anemia, stunting, underweight, and wasting at baseline and after 2 y and adjusted DID impact estimates for these indicators among children 3–12.9 mo of age at baseline whose families lived in control, OWL, and HC villages[1]

| Variable | Control | OWL | DID | P | HC | DID | P |
|---|---|---|---|---|---|---|---|
| Hb, g/dL, N | 530 | 410 | | | 391 | | |
| Baseline | 9.09 ± 1.65 | 8.71 ± 1.77 | | | 8.8 ± 1.74 | | |
| End line | 9.68 ± 1.42 | 9.64 ± 1.48 | 0.24 ± 0.31 | 0.45 | 9.89 ± 1.43 | 0.51 ± 0.27 | 0.06 |
| Anemic (Hb < 11.0 g/dL) | | | | | | | |
| Baseline, n (%) | 475 (89.6) | 369 (90.0) | | | 342 (87.5) | | |
| End line, n (%) | 434 (81.8) | 330 (80.6) | −1.2 pp | 0.83 | 303 (77.5) | −3.4 pp | 0.43 |
| Severely anemic (Hb < 7.0 g/dL) | | | | | | | |
| Baseline, n (%) | 53 (10.0) | 66 (16.1) | | | 59 (15.0) | | |
| End line, n (%) | 13 (2.5) | 17 (4.2) | −2.4 pp | 0.52 | 11 (2.9) | −3.3 pp | 0.29 |
| HAZ, N | 475 | 378 | | | 350 | | |
| Baseline | −1.29 ± 1.49 | −1.06 ± 1.64 | | | −1.35 ± 1.62 | | |
| End line | −1.91 ± 1.10 | −1.77 ± 1.21 | −0.07 ± 0.17 | 0.69 | −1.96 ± 1.09 | 0.07 ± 0.14 | 0.60 |
| Stunted (HAZ < −2 SDs) | | | | | | | |
| Baseline, n (%) | 144 (30.3) | 108 (28.5) | | | 117 (33.5) | | |
| End line, n (%) | 227 (47.7) | 165 (43.5) | −3.2 pp | 0.57 | 165 (47.0) | −4.6 pp | 0.39 |
| WAZ, N | 492 | 366 | | | 339 | | |
| Baseline | −1.63 ± 1.68 | −1.41 ± 1.57 | | | −1.73 ± 1.59 | | |
| End line | −1.53 ± 1.14 | −1.44 ± 1.04 | −0.05 ± 0.14 | 0.72 | −1.62 ± 1.01 | 0.16 ± 0.12 | 0.20 |
| Underweight (WAZ < −2 SDs) | | | | | | | |
| Baseline, n (%) | 194 (39.5) | 117 (31.9) | | | 141 (41.5) | | |
| End line, n (%) | 154 (31.4) | 97 (26.5) | 0.1 pp | 0.99 | 106 (31.3) | −4.4 pp | 0.26 |
| WHZ, N | 468 | 359 | | | 330 | | |
| Baseline | −0.96 ± 1.79 | −0.98 ± 1.82 | | | −1.16 ± 1.82 | | |
| End line | −0.66 ± 1.25 | −0.66 ± 1.06 | 0.02 ± 0.19 | 0.93 | −0.73 ± 1.00 | 0.17 ± 0.15 | 0.25 |
| Wasted (WHZ < −2 SDs) | | | | | | | |
| Baseline, n (%) | 114 (24.3) | 92 (25.7) | | | 102 (30.8) | | |
| End line, n (%) | 48 (10.2) | 30 (8.4) | −3.8 pp | 0.42 | 28 (8.6) | −8.8 pp | 0.08 |
| Diarrhea prevalence, N | 521 | 402 | | | 391 | | |
| Baseline, n (%) | 89 (17.1) | 107 (26.6) | | | 123 (31.4) | | |
| End line, n (%) | 63 (12.1) | 57 (14.3) | −9.8 pp | 0.05 | 47 (12.0) | −15.9 pp | 0.00 |

[1] All unadjusted baseline and end line values are means ± SDs or percentages. Age of children at end line was 24–39.9 mo. DID, difference-in-difference; Hb, hemoglobin concentration; HAZ, height-for-age z score; HC, health committee; OWL, older woman leader; pp, percentage point; WAZ, weight-for-age z score; WHZ, weight-for-height z score.

**TABLE 3** Unadjusted mean Hb, HAZ, WAZ, and WHZ and prevalence of anemia, severe anemia, stunting, underweight, and wasting at baseline and after 2 y and adjusted DID impact estimates for these indicators among children 3–5.9 mo of age at baseline whose families lived in control, OWL, and HC villages[1]

| Variable | Control | OWL | DID | P | HC | DID | P |
|---|---|---|---|---|---|---|---|
| Hb, g/dL, *N* | 200 | 174 | | | 148 | | |
| Baseline | 9.31 ± 1.72 | 9.06 ± 1.72 | | | 8.87 ± 1.67 | | |
| End line | 9.58 ± 1.38 | 9.4 ± 1.55 | 0.10 ± 0.34 | 0.77 | 9.87 ± 1.56 | 0.76 ± 0.33 | 0.02 |
| Anemic (Hb < 11.0 g/dL) | | | | | | | |
| Baseline, *n* (%) | 171 (85.7) | 152 (87.6) | | | 134 (90.3) | | |
| End line, *n* (%) | 172 (86.2) | 144 (82.9) | −5.9 pp | 0.28 | 114 (76.8) | −14.6 pp | 0.02 |
| Severely anemic (Hb < 7.0 g/dL) | | | | | | | |
| Baseline, *n* (%) | 17 (8.7) | 21 (12.1) | | | 21 (14.1) | | |
| End line, *n* (%) | 5 (2.5) | 11 (6.4) | 0.5 pp | 0.92 | 6 (3.8) | −1.7 pp | 0.72 |
| HAZ, *N* | 189 | 163 | | | 136 | | |
| Baseline | −0.82 ± 1.48 | −0.58 ± 1.81 | | | −0.70 ± 1.59 | | |
| End line | −1.95 ± 1.17 | −1.91 ± 1.23 | −0.17 ± 0.27 | 0.54 | −1.87 ± 1.01 | 0.06 ± 0.21 | 0.79 |
| Stunted (HAZ < −2 SDs) | | | | | | | |
| Baseline, *n* (%) | 45 (23.9) | 40 (24.5) | | | 28 (20.8) | | |
| End line, *n* (%) | 93 (49.2) | 79 (48.4) | −2.9 pp | 0.68 | 59 (43.0) | −5.9 pp | 0.38 |
| WAZ, *N* | 191 | 158 | | | 132 | | |
| Baseline | −1.18 ± 1.59 | −1.22 ± 1.57 | | | −1.16 ± 1.55 | | |
| End line | −1.71 ± 1.08 | −1.56 ± 0.99 | 0.13 ± 0.19 | 0.49 | −1.57 ± 0.95 | 0.19 ± 0.20 | 0.37 |
| Underweight (WAZ < −2 SDs) | | | | | | | |
| Baseline, *n* (%) | 52 (27.5) | 45 (28.6) | | | 34 (25.5) | | |
| End line, *n* (%) | 68 (35.8) | 50 (31.8) | −4.8 pp | 0.55 | 37 (28.4) | −6.1 pp | 0.40 |
| WHZ, *N* | 182 | 155 | | | 131 | | |
| Baseline | −0.84 ± 1.83 | −0.96 ± 1.94 | | | −0.8 ± 1.69 | | |
| End line | −0.91 ± 1.31 | −0.73 ± 1.03 | 0.20 ± 0.26 | 0.45 | −0.76 ± 0.92 | 0.10 ± 0.25 | 0.68 |
| Wasted (WHZ < −2 SDs) | | | | | | | |
| Baseline, *n* (%) | 41 (22.3) | 44 (28.6) | | | 29 (22.1) | | |
| End line, *n* (%) | 22 (12.3) | 15 (9.8) | −7.5 pp | 0.23 | 15 (11.2) | −2.1 pp | 0.76 |
| Diarrhea prevalence, *N* | 194 | 174 | | | 145 | | |
| Baseline, *n (%)* | 28 (14.3) | 37 (21.1) | | | 30 (20.6) | | |
| End line, *n* (%) | 24 (12.4) | 20 (11.5) | −8.3 pp | 0.18 | 17 (11.6) | −9.8 pp | 0.12 |

[1] All unadjusted baseline and end line values are means ± SDs or percentages. Age of children at end line was 24–32.9 mo. DID, difference-in-difference; Hb, hemoglobin concentration; HAZ, height-for-age *z* score; HC, health committee; OWL, older woman leader; pp, percentage point; WAZ, weight-for-age *z* score; WHZ, weight-for-height *z* score.

at baseline (DID: 0.76 g/dL; *P* = 0.02) (**Table 3**). In addition, there was a 14.6-pp greater decrease in the prevalence of anemia (*P* = 0.02) among these younger children in HC villages than in control villages (**Figure 2**A, Table 3). A statistically significant −15.9-pp difference was also found in the reduction of diarrhea among children 3–12.9 mo of age living in HC villages compared with control villages. A similar trend was seen among children living in OWL villages compared with control villages, although the difference between the 2 groups was smaller (−9.8 pp) and was only marginally statistically significant (*P* = 0.05) (Table 2). Program impacts on anthropometric measures were restricted to a marginally statistically significant 8.8-pp (*P* = 0.08) greater decrease in the prevalence of wasting among children 3–12.9 mo of age at baseline in the HC villages than in the control villages (Table 2, Figure 2B).

*Pathways of impact.* Along the 2 primary program pathways examined in this study, from production of micronutrient-rich foods to intake and from improvements in knowledge to adoption of optimal IYCF practices, we found statistically significant positive impacts on some key intermediary outcomes. For example, in HC and OWL villages compared with control villages we found statistically significant greater increases in women's production of vitamin A–rich fruits and vegetables and other fruits and vegetables, the foods primarily promoted by the E-HFP activities (**Supplemental Table 1**). In addition, we found significantly greater improvements in women's knowledge of IYCF practices and in the percentage of women who reported washing their hands before feeding their child (**Table 4**). These changes translated into marginally statistically significant greater increases in household dietary diversity scores (DID: 0.8; *P* = 0.07) and in the percentage of children between 6 and 12.9 mo of age at baseline who received ≥4 food groups (minimum dietary diversity) in the past 24 h (DID: 12.6 pp; *P* = 0.08) in the HC villages than in the control villages (Table 4). At end line, children who had received ≥4 food groups in the past 24 h compared with children who had not were more likely to have had legumes (88% vs. 5%), milk (11% vs. 1%), eggs (7% vs. 1%), flesh foods (99% vs. 48%), vitamin A–rich foods (97% vs. 67%), and other fruits and vegetables (4% vs. 2%) in the past 24 h (results not shown).

## Discussion

This study is the first cluster-randomized controlled trial of an integrated agriculture and BCC program that documents statistically significant impacts on child Hb, anemia, and diarrhea and

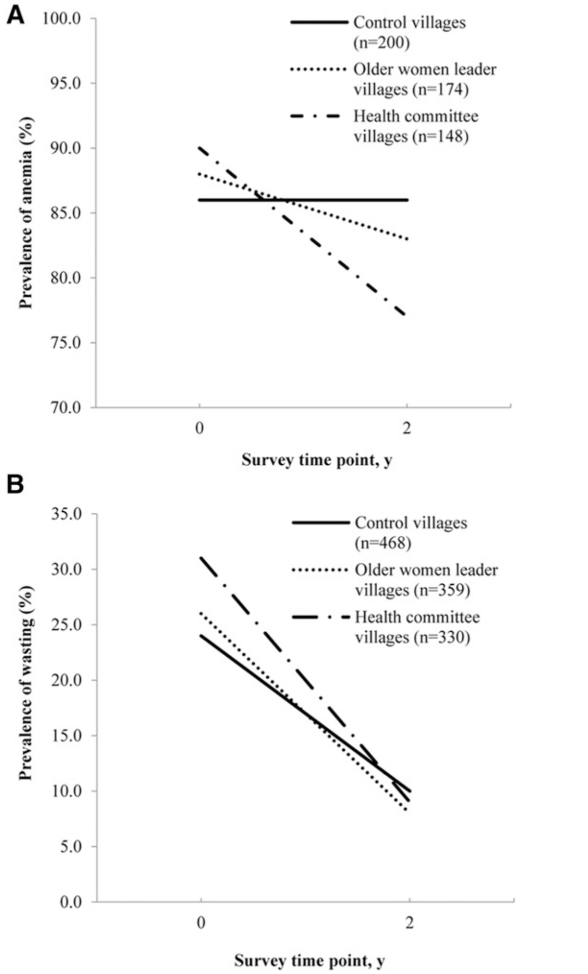


**FIGURE 2** Unadjusted mean prevalence of anemia (hemoglobin < 11.0 g/dL; A) and of wasting (weight-for-height $z$ score < −2 SDs; B) at baseline and after 2 y among children 3–5.9 and 3–12.9 mo of age at baseline, respectively, whose families lived in the control, older woman leader, or health committee villages (1, 2).

marginally statistically significant effects on wasting. The plausibility of the findings is supported by statistically significant positive impacts on intermediary outcomes along the program impact pathways, including increases in women's agriculture production and health- and nutrition-related knowledge and practices in HC villages compared with control villages.

Although the impacts documented in this study on 2 of the most severe nutritional problems in the country are meaningful and encouraging, the prevalence of anemia and wasting in HC villages at end line was still high (77% and 9%, respectively), and no statistically significant program effects were found on the prevalence of stunting or underweight. Several explanations are possible for the relatively modest impacts found, including the short 2-y duration of the program and a lag time between the baseline survey and full program implementation, which meant that children likely did not fully benefit from all program components (including availability of vegetables grown in the home gardens and increased knowledge from the BCC intervention) until they were between 11 and 20.9 mo of age. Agriculture programs require several months of start-up time before impacts on production and consumption can be observed; similarly, BCC interventions in IYCF and health, which aim at modifying maternal health and nutrition-related knowledge and behaviors, may require relatively long exposure time for knowledge acquisition and translation into optimal behaviors (25). Despite these program constraints, we observed moderate impacts on changes in agriculture production, knowledge, and adoption of optimal IYCF practices and in household dietary diversity. It is possible that larger impacts on these intermediary outcomes and on children's nutrition and health outcomes would have been achieved with earlier and longer exposure to the program. This is especially true for stunting, which is a cumulative process that requires sustained optimal diets (of the mother) and IYCF (of the child) and infection control during the whole period from pregnancy through the child's second birthday (26). Nonetheless, the modest impacts achieved over a 2-y period from an E-HFP and BCC program are meaningful and hold promise for future investments in integrated agriculture and nutrition programs.

Our study highlights 3 critical program design and implementation aspects that could help maximize impact: targeting, timing, and intervention package. The focus on the first 1000 d emphasizes the need to target nutrition and health interventions as early as possible during pregnancy and to ensure regular contacts with the mother and child until the child's second birthday. In our study it was not possible to target women during pregnancy, and sample sizes prevented us from targeting a narrower age range of children as originally planned (3–9 mo of age). Our marginally significant impacts on wasting prevalence and lack of impact on stunting are compatible with current understanding of the ideal timing and duration of interventions for the prevention of linear growth retardation (26–28). The same is true for our findings of a larger impact among younger children (3–5.9 mo) at baseline for Hb and anemia. If targeted earlier (e.g., during pregnancy), the program could have helped prevent some of the childhood stunting associated with intrauterine growth retardation (estimated to explain ∼20% of the stunting in children <5 y of age) (29). On the basis of our findings, other aspects of the program package that could also be strengthened include hygiene and sanitation BCC to further reduce diarrhea and intensifying malaria prevention, including through the promotion of use of insecticide-treated bed nets, to further reduce anemia (10). In addition, fortified complementary foods or products or more intensive agricultural interventions may be needed to prevent childhood anemia and to promote optimal growth in this population, given the severity of child undernutrition and food insecurity in Burkina Faso (30). Overall, it is clear that the program would require >2 y of operation and renewed efforts to ensure that BCC is effective at transferring knowledge and eliciting adoption of optimal practices and that complementary interventions are incorporated in the program to help address some of the severe socioeconomic and food access constraints faced by the population.

Our findings show that the HC group was effective at improving children's nutritional status, whereas the OWL group was not. In addition, we found a marginally significant program impact on improving children's dietary diversity in the HC group compared with the control group and a similar, but not significant, increase in the OWL group compared with the control group. However, the results related to increases in the proportion of women who were knowledgeable about key IYCF and care practices were similar across the 2 groups relative to the control group. Given the small differences on some of the intermediary outcomes between the HC and OWL groups it is likely that other factors contributed to the improvements in Hb and the observed declines in anemia and wasting. Examples of such factors could include a greater utilization of health services among households in HC villages compared with control or OWL villages or greater adoption of other important health, hygiene, or nutrition practices that were not measured in the

**TABLE 4** Unadjusted mean prevalence of women's knowledge and practices related to hygiene and key IYCF behaviors and adjusted DID impact estimates for these indicators among mothers of children 3–12.9 mo of age at baseline whose families lived in control, OWL, and HC villages[1]

| Variable | Control | OWL | DID, pp | *P* | HC | DID, pp | *P* |
|---|---|---|---|---|---|---|---|
| Knowledge about IYCF practices, *N* | 529 | 403 | | | 395 | | |
| Children should be fed < 1 h after birth | | | | | | | |
| Baseline | 240 (45.4) | 179 (44.5) | | | 174 (44.0) | | |
| End line | 376 (71.2) | 347 (86.2) | 14.1 | 0.16 | 349 (88.4) | 17.1 | 0.08 |
| Children should begin receiving liquids at 6 mo of age | | | | | | | |
| Baseline | 205 (39.1) | 103 (25.6) | | | 129 (33.0) | | |
| End line | 292 (55.6) | 273 (67.8) | 28.2 | 0.00 | 296 (75.8) | 27.3 | 0.00 |
| Children should begin receiving semisolid foods at 6 mo of age | | | | | | | |
| Baseline | 223 (42.4) | 135 (33.5) | | | 154 (39.1) | | |
| End line | 333 (63.1) | 293 (73.0) | 18.1 | 0.00 | 300 (76.0) | 15.9 | 0.04 |
| Knowledge of hand washing times, *N* | 526 | 402 | | | 392 | | |
| Before eating | | | | | | | |
| Baseline | 297 (56.5) | 216 (53.7) | | | 217 (55.3) | | |
| End line | 348 (66.1) | 250 (62.2) | 0.5 | 0.93 | 272 (69.5) | 5.2 | 0.44 |
| After using the toilet | | | | | | | |
| Baseline | 75 (14.2) | 68 (16.9) | | | 73 (18.6) | | |
| End line | 38 (7.2) | 46 (11.4) | 1.4 | 0.73 | 49 (12.5) | 1.2 | 0.76 |
| Before feeding a child | | | | | | | |
| Baseline | 235 (44.7) | 116 (28.8) | | | 140 (35.7) | | |
| End line | 167 (31.8) | 127 (31.7) | 13.9 | 0.04 | 176 (44.9) | 22.2 | 0.01 |
| After cleaning a child who has defecated | | | | | | | |
| Baseline | 77 (14.6) | 90 (22.5) | | | 71 (18.1) | | |
| End line | 23 (4.4) | 18 (4.6) | −10.6 | 0.08 | 21 (5.5) | −4.7 | 0.39 |
| IYCF practices,[2] *N* | 307 | 220 | | | 231 | | |
| Minimum dietary diversity | | | | | | | |
| Baseline | 8 (2.6) | 7 (3.0) | | | 4 (1.7) | | |
| End line | 20 (6.3) | 35 (15.0) | 8.3 | 0.17 | 43 (18.2) | 12.6 | 0.08 |
| Intake of iron-rich foods | | | | | | | |
| Baseline | 26 (8.4) | 22 (10.2) | | | 23 (9.9) | | |
| End line | 156 (50.9) | 139 (63.3) | 10.7 | 0.17 | 121 (52.4) | 0.1 | 0.99 |

[1] All unadjusted baseline and end line values are *n* (%). Age of children at end line was 24–39.9 mo. DID, difference-in-difference; HC, health committee; IYCF, infant and young child feeding; OWL, older woman leader; pp, percentage point.
[2] IYCF practices for children 6–12.9 mo at baseline.

survey but that may have been related to the differences in knowledge, efficacy, or influence of the actors who delivered the BCC messages. For example, qualitative data from our process evaluation indicated that HC actors were more knowledgeable about anemia-related topics than OWL actors and that HC actors generally felt more confident in their knowledge and were more likely than actors in OWL villages to follow up with their beneficiary women to check adoption of optimal practices (31).

Although this study has many strengths, including the use of a cluster-randomized control trial and analyses of program impact pathways, there are a few limitations. The first is the lack of data on malaria infection and use of bed nets, which could have helped us better understand the impacts found on anemia. Another limitation is the small sample size of children 3–9 mo of age, which led us to extend the age range up to 12 mo. Our findings suggest that indeed greater impacts could be achieved on anemia and Hb among younger children (3–6 mo). These shortfalls were largely because of financial constraints that limited the number of villages that could be included in the E-HFP program, the duration of the program (which limited our ability to extend the period of enrollment in the study), and the broad scope of the study, which led to long survey questionnaires (and explains the lack of inclusion of questions on bed net ownership and use). Finally, it is important to note that our study findings are specific to villages with similar characteristics as villages included in the study and may not be replicable in villages with different characteristics such as the lack of access to an operational dry season water source.

A unique feature of the types of agriculture and nutrition programs evaluated in this study is the fact that they include agriculture training and specific BCC activities aimed at empowering women with skills and knowledge that can have both short- and long-term benefits for the women themselves and for their present and future children. For example, additional analyses of the data found that the program improved women's ownership and control of productive assets (32). These impacts on key aspects of women's empowerment are likely to be transformational and to have long-lasting benefits for women, their children, and their households and for their broader communities. Short-term evaluations fail to capture such impacts.

Given the positive short-term impacts on children's nutrition outcomes and the potential for longer-term benefits for participating women and their families, evaluations of gender-sensitive integrated agriculture and nutrition programs should be performed over longer periods than the 2 y allocated here to unveil their real potential to contribute to improving maternal and child nutrition. Evaluation designs should also include mid- and long-term assessments of spill-over effects and sustainability. Short-term evaluations such as the one presented here likely underestimate the overall impacts of these programs on multiple outcomes, which may be fully achieved long after the key program inputs have been delivered.


## Acknowledgments

We thank Lilia Bliznashka and Esteban Quiñones for their contribution to the analysis of the quantitative data and Jef Leroy for feedback on some of the quantitative analyses. Lastly, we thank Jennifer Nielsen, Marcellin Ouedraogo, Abdoulaye Pedhemboga, Hippolyte Rouamba, Ann Tarini, Dr. Jean Celestin Somda, Olivier Vebamba, and Fanny Yago-Wienne for overseeing and implementing the program and for their collaboration. DKO, MTR, and AD designed the evaluation with input from AP; DKO, AP, and AD led the data collection activities; DKO and AD led the data analyses; DKO, MTR, and AD drafted the manuscript; DKO, AP, MTR, and AD contributed to interpreting the results from the evaluation presented here; DKO, AP, MTR, and AD had full access to the data; DKO had final responsibility for submitting this article for publication. All authors read and approved the final manuscript.


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