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What it takes: evidence from a nutrition- and gender-sensitive agriculture intervention in rural Zambia

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ABSTRACT

The Realigning Agriculture for Improved Nutrition (RAIN) project was designed to address child undernutrition through a multisectoral approach which integrated agricultural diversification to improve access to nutritious foods, the promotion of gender equality and women's empowerment and nutrition behaviour change communication to improve infant and young child feeding (IYCF) knowledge and practices. This paper presents the intention-to-treat impacts of the RAIN project on women's empowerment, IYCF knowledge and practices and child anthropometry. Findings on programme impacts on agricultural production, household food security and dietary diversity and maternal and child dietary diversity are reported elsewhere. The RAIN project had positive effects on women's empowerment, IYCF knowledge, child morbidity and weight-for-height *z*-scores, but had little impacts on IYCF practices, and no impact on stunting. Strengthening programme implementation and fostering higher participation rates could support greater impacts on child nutrition outcomes.

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Women's empowerment; agriculture; infant and young child feeding; child undernutrition; Zambia; gender

Introduction

Child undernutrition is caused by a combination of complex factors, summarised as insufficient quantity and quality of food, poor health and suboptimal childcare and feeding practices or *food, health and care* (UNICEF 1990). Nutrition interventions are traditionally delivered through the health sector, but it has been acknowledged that addressing malnutrition and its direct and underlying determinants requires involvement from many other sectors, including agriculture (Bhutta et al. 2008). Recent international strategies have therefore promoted the integration of nutrition-specific interventions such as the promotion of optimal infant and young child feeding (IYCF) practices or micronutrient supplementation within broader, nutrition-sensitive programmes and policies, including those promoting agricultural production diversity and supporting the empowerment of women (SCN 2011). This paper presents results from a cluster-randomised impact evaluation of a nutrition- and gender-sensitive agriculture development programme implemented by Concern Worldwide in Zambia.

Agriculture may affect child nutrition through various theoretical pathways, including the production of food to be directly consumed by the household or sold for income, and through various gender-specific pathways including women's social status and empowerment, time use and nutrition and health status (Gillespie, Harris, and Kadiyala 2012; WB 2007; Herforth and Harris 2014).

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Small-scale homestead food production programmes aimed at increasing access to nutritious foods have been found to support livelihoods and food security and proposed as potentially useful platforms for delivering nutrition-specific interventions targeted to women and young children (Ruel, Alderman, and Maternal 2013). Evidence of the effectiveness of these programmes in improving nutrition outcomes, however, is scarce, in part due to poor programme and evaluation designs as noted in several reviews (Girard et al. 2012; Masset et al. 2012). One recent study in Burkina Faso using a randomised controlled trial evaluation design showed that a well-designed and implemented gender-sensitive homestead food production programme with nutrition behaviour change communication (BCC) had significant impacts on women's empowerment as well as on nutrition and health outcomes among children and their mother (Olney et al. 2016; Olney et al. 2015).

Built upon the conceptual links between agriculture, women's empowerment and nutrition, the Realigning Agriculture for Improved Nutrition (RAIN) project was a partnership between Concern Worldwide and the International Food Policy Research Institute, aimed to design, implement and evaluate a gender-sensitive agricultural programme combined with nutrition BCC targeted to the primary caregivers of children during their critical first two years of life, in Mumbwa district, Zambia. This paper presents the impacts of the programme on stunting (main outcome) and on women's empowerment, IYCF knowledge and practices and child morbidity, wasting, height-for-age *z*-scores (HAZ) and weight-for-height *z*-scores (WHZ) (secondary outcomes). A separate paper (Rosenberg et al. 2017) reports findings on the impacts of the programme on agricultural production, household food security and dietary diversity and maternal and child dietary diversity.

The Zambian context

Zambia ranks low on most measures of national income, poverty and inequality, and the Government therefore sees little financial revenue for provision of services. Zambia also ranks poorly on human development indicators, with a young, rural and very sparsely spread population, low life expectancy and poor gender equity (Central Statistical Office, Ministry of Health, Tropical Diseases Research Centre, University of Zambia, and Macro International Inc 2009; UNDP 2011). Agricultural productivity is low largely due to poverty and poor infrastructure; production of maize is heavily promoted in Government policy and programmes and is the predominant cash and subsistence crop, with food security in Zambia generally equated to 'maize security' (Smale and Jayne 2009). The Global Hunger Index in 2015 (year of the RAIN endline survey) (Grebmer et al. 2015) ranks Zambia as having an 'extremely alarming' hunger situation and highlights major deficits in nutrition and child survival.

Around 75 per cent of Zambia's rural poor are small-scale farmers relying almost entirely on subsistence agriculture, and a further 20 per cent are classed as emergent, with some surplus available for sale but consuming a large proportion of what they grow (FAO 2009; Sitko and Jayne 2012). Agriculture revolves around a few staple crops, and maize is predominant in terms of both production and consumption; in 2009, maize accounted for 86 per cent of cereal production and 49 per cent of total calorie availability per capita in the country; cassava, another starchy staple, accounted for a further 14 per cent of calories (FAO 2014). Zambian agricultural policies revolve around large input subsidy programmes and large-scale government maize procurement through the Food Reserve Agency, promoting maize production to the exclusion of most other crops; although other crops have recently been incorporated into this system, and nutrition is gradually being written into high-level strategy documents within the agriculture sector, there is as yet little sign that the emphasis on maize is due to change soon in any practical sense (Harris and Drimie 2012).

Because of this focus on staple food production and poor access to markets, rural Zambian diets are monotonous and generally lack the diversity required for good nutrition.

Child health indicators and intervention coverage in Zambia are poor but have been improving slowly. Fertility rates (6.2 per woman) are very high, and relatedly the under-five mortality rate is at 75 per 1000 live births. Fifty-eight per cent of children are fully vaccinated at 12 months, and only

around half of children who suffer from diarrhoea, fever or pneumonia receive appropriate treatment (Central Statistical Office, Ministry of Health, Tropical Diseases Research Centre, University of Zambia, and Macro International Inc 2014). Use of improved drinking water sources is low (85% urban and 49% rural), as is access to improved sanitation (56% urban and 34% rural) (UNICEF 2015). Vitamin A supplementation is relatively high nationally (80–90% for children under one year), but pockets of poor coverage persist.

The prevalence of stunting in Zambia had increased from 1990 to 2001 and then declined 13 percentage points (pp) from 2002 to 2014 (from 53% to 40%) (Central Statistical Office, Ministry of Health, Tropical Diseases Research Centre, University of Zambia, and Macro International Inc 2014); the most recent Demographic and Health Surveys (DHS) survey shows a reduction in stunting to 40 per cent nationally (Central Statistical Office, Ministry of Health, Tropical Diseases Research Centre, University of Zambia, and Macro International Inc 2014). IYCF practices are variable, with 74 per cent of children under six months exclusively breastfed, but only 11 per cent being fed appropriately for their age (Central Statistical Office, Ministry of Health, Tropical Diseases Research Centre, University of Zambia, and Macro International Inc 2014). Chronic malnutrition is prioritised in the National Food and Nutrition Strategic Plan (National Food and Nutrition Commission of Zambia 2011), and the Sixth National Development Plan explicitly mentions nutrition as an essential cross-cutting issue for achieving the country's socio-economic development.

The RAIN project and its theory of change

The RAIN project was implemented in Mumbwa district in Zambia between 2011 and 2015. Mumbwa is a rural district in Central Province of Zambia located approximately two hours from the capital Lusaka, with a good road connection but little in the way of local transport or energy infrastructure. Stunting in Central Province was slightly higher than the national average, at 42.5 per cent compared to 40 per cent for the country as a whole, according to the latest Demographic and Health Survey from 2013 to 2014 (Central Statistical Office, Ministry of Health, Tropical Diseases Research Centre, University of Zambia, and Macro International Inc 2014).

At the onset of the study, Concern Worldwide established partnerships with relevant government line ministries and with local implementing NGOs who were to deliver programme content across the different project components. The project comprised of an agriculture intervention focused on homestead food production to increase year-round availability of, and access to, nutrient-rich foods at the household level. This was provided to the intervention groups, along with a gender awareness and women's empowerment intervention. Additionally, in randomly selected intervention areas, a nutrition BCC component focused on the promotion of optimal IYCF knowledge and practices was implemented.

The agriculture component of the project aimed to promote dietary diversity in a population generally consuming a maize-centric, monotonous diet low in micronutrients. The agriculture intervention focused on home gardening and provided nutrient-rich vegetable, legume and tuber seeds along with agricultural tools and training. A small animal component also included the provision of chickens and goats along with training on animal husbandry. The agriculture component was delivered through local women's groups created by the programme and consisting of women who either were pregnant or had a child below the age of 18 months at enrolment. The group was led by a female Smallholder Model Farmer (SMF) nominated by her group to receive initial inputs and agricultural training from project staff and government extension workers and pass both inputs and knowledge on to the group during regular meetings. Seeds were distributed to all group members, and the groups received a food solar drier and a treadle pump.

The nutrition BCC component of the programme aimed to build on the high breastfeeding rates in the country (exclusive breastfeeding at 61%) (Central Statistical Office, Ministry of Health, Tropical Diseases Research Centre, University of Zambia, and Macro International Inc 2009) and improve complementary feeding practices. The nutrition BCC was focused on the promotion of optimal IYCF knowledge and practices, hygiene and preventive health-seeking behaviours. Existing

government Community Health Volunteers (CHVs) received initial trainings in IYCF and monthly refresher trainings, using existing government IYCF guidelines and materials. The IYCF materials included messages on optimal hygiene practices and reminders about seeking curative as well as preventive healthcare at the health centres. In the group that received the BCC intervention, the RAIN women's groups were linked to a retrained CHVs who led BCC sessions during their meetings. Both SMFs and CHVs were tasked with following-up group meetings with one-to-one home visits on specific nutrition-related topics.

The RAIN intervention also aimed to improve norms around gender equality and women's empowerment more broadly in target communities, so that improved nutrition and agricultural knowledge coupled with improvements in women's status could lead to positive changes in child feeding practices. Thus, in addition to the group-focused activities, there were various activities to promote women's empowerment and gender equality, developed from an initial gender analysis and including both men and women from the communities in the programme intervention groups. In addition to the group-focused activities, spouses were invited to discuss gender-related topics; community sensitisations were undertaken with assistance from drama groups, particularly around gender equality and its importance for improved nutrition; posters and brochures were developed and shared to promote the contribution of fathers in ensuring good nutrition of their family members and preventive and curative health seeking behaviours; and a gender programme was broadcast on the local radio. In addition, fuel-saving stoves were trialled as labour-saving technologies, and fuel trees were given as inputs to participants, with the intention of saving women's time.

Figure 1 presents the theory of change for the RAIN project. It outlines the inputs delivered through the intervention in the two treatment arms. As noted above, the programme started out by identifying SMFs and women's groups and using them to deliver agricultural training and inputs. All SMFs and women's groups also received the gender training. It was envisaged that these inputs would lead to a number of processes which in turn would lead to outputs and outcomes that would eventually improve nutrition outcomes among children less than 24 months of age. The processes triggered would include increased diversity of production in home gardens, increased diversity of crop cultivation, increased rearing of poultry and other livestock and increased awareness of gender equality and improvements in gender norms. These processes would lead to a combination of outputs such as increased food production, increased sale of food and thus increased household income, increased women's decision-making power and overall improvements in women's empowerment. These outputs, in turn, would lead to improved

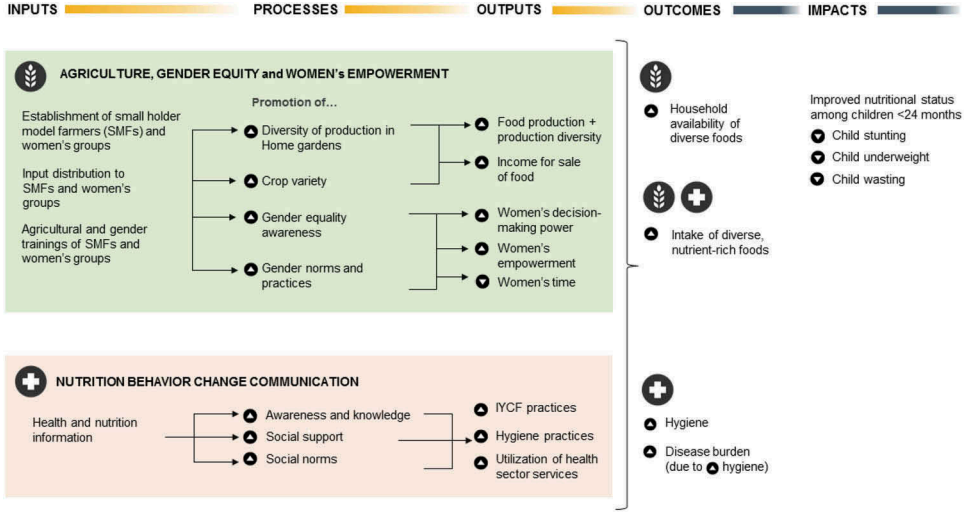

Figure 1. RAIN project theory of change.

household access to, and consumption of, food and diverse diets (increasing household food security) and improved maternal and child diet quality which in turn would improve nutritional status among young children.

The treatment arm that, in addition to the agriculture and gender trainings, also received the nutrition BCC has additional inputs that would lead to a linked yet separate stream of processes, outputs and outcomes which would also lead to improved nutrition outcomes among children under 24 months of age. The nutrition BCC intervention focused on promoting optimal IYCF practices would increase awareness and knowledge among the primary care givers of children. The delivery of BCC through group trainings also may convey the additional benefits of providing mothers with access to social support (through the group) and facilitating changes in social norms around IYCF. These processes are expected to lead to improved IYCF and hygiene practices and increased utilisation of health services. Improved IYCF practices, combined with greater access to a diversity of nutrient-rich foods, (through production) are expected to lead to increased dietary diversity (and likelihood of meeting high nutrient requirements) among young children. The BCC would, in addition, lead to improved hygiene and a reduced disease burden. This would ultimately improve nutritional status among young children.

An important objective of adding the nutrition BCC to the RAIN agriculture and women's empowerment-focused programme was to make the programme more nutrition sensitive and focused on the nutrition needs of the young child, in an effort to achieve greater impacts on child nutritional status outcomes.

Methods

Evaluation design

A cluster-randomised, controlled, non-blinded, impact evaluation design was used to compare the impact of two RAIN intervention packages on maternal and child outcomes. [1] The three randomly assigned groups received the following interventions: (1) Agriculture, gender equity and women's empowerment (Ag-G group); (2) Agriculture, gender equity and women's empowerment plus nutrition BCC interventions (Ag-G-BCC); and (3) Standard government services (including maize-focused agricultural extension targeted predominantly to male farmers, antenatal care visits by CHVs and growth monitoring for under 5-year-old children) (Control). A cross-sectional household survey was conducted at baseline (2011) and at the same time of the year at endline (2015) in the same communities, among households with children 0–59.9 months of age. The two main goals of the study were to (1) document impacts on stunting (main outcome) and women's empowerment, IYCF knowledge and practices and child morbidity, wasting, HAZ and WHZ (secondary outcomes) over 4 years of programme implementation in the two RAIN project intervention areas compared to the control area; and (2) determine the added benefit of the BCC nutrition intervention to the agricultural and gender interventions and relative to the control group.

Given the 4-year duration of the RAIN project, children between 24 and 48 months of age at endline had the highest probability of having been exposed to the programme for the whole first two years of their life and thus had the greatest potential to benefit from the intervention. For this reason, we restricted the analysis of impacts on stunting to the subsample of children 24–48 months of age (2243 children at baseline and 2346 at endline). Power calculations done for this sample size yielded a detectable difference of 7pp in stunting between baseline and endline between study groups.[2]

Outcomes

The study's main outcome was child stunting. Secondary outcomes reported in this paper are (1) women's empowerment measured on different domains; (2) maternal knowledge related to

recommended IYCF practices for children 0–23.9 months of age; (3) maternal reported IYCF practices based on the World Health Organization (WHO) core set of indicators (WHO 2008); (4) child morbidity symptoms (fever, cough/cold and diarrhoea); and (5) child wasting, HAZ and WHZ.

Women's empowerment was measured on seven domains including social capital, communication with spouse, perceptions of gender equality, intrahousehold decision-making, access to and control over assets, access to savings/credit and agriculture. The domains we used to measure women's empowerment are closely aligned with the domains included in the Women's Empowerment in Agriculture Index (WEAI) (Alkire et al. 2013). However, we did not use the WEAI definitions or questionnaire modules as these were not available at the time of our baseline survey. To maintain consistency across questions in the two survey rounds, we administered the same modules in the endline, even though the WEAI was available at that time. Our time allocation data (measured only at endline) was collected using the module from the abbreviated WEAI. Table A2 provides a summary of the content of each of the seven domains included in our measurement of women's empowerment and related scores. For each domain, an aggregate score was constructed by averaging scores across the variables within domains (Harris et al. 2016b). A higher score indicates higher empowerment. In addition to these empowerment variables, we also constructed a measure of total time spent by the women on different activities such as agricultural work, domestic work, leisure activities and all other work. This measure is based on data collected on a 24-hour recall of all activities undertaken in the day before the survey and was collected only at endline.

Child IYCF practices were measured using maternal recall of practices related to breastfeeding and complementary feeding using eight IYCF indicators recommended by the WHO (WHO 2008): (1) early initiation of breastfeeding (proportion of 0–23-month-old children who were put to the breast within one hour of birth); (2) exclusive breastfeeding (proportion of infants 0–5-month old who were fed exclusively with breastmilk in previous 24 h); (3) continued breastfeeding at 1 year (proportion of children 12–15-month old who were breastfed in previous 24 h); (4) minimum dietary diversity (proportion of children 6–23 months of age who consumed foods from four or more (out of 7) food groups in previous 24 h); (5) minimum meal frequency as appropriate for age and for breastfeeding status; (6) minimum acceptable diet (proportion of children 6–23 months of age who had minimum acceptable diet (apart from breast milk)); (7) consumption of iron-rich or iron-fortified foods (proportion of children 6–23 months of age who consumed iron-rich or iron-fortified foods in previous 24 h); and (8) timely introduction of solid, semi-solid or soft foods (proportion of children 6–8 months of age who received solid, semi-solid or soft foods in previous 24 h) (WHO 2008).

IYCF knowledge was assessed based on the mothers' answers to a series of questions related to knowledge on established IYCF practices. These include key areas of knowledge on breastfeeding (such as early initiation of breastfeeding, exclusive breastfeeding up to six months and breastfeeding her baby until 24 months) and on complementary feeding (such as timely initiation of various complementary foods). Each knowledge item was given a score of 1 (correct) or 0 (incorrect), and the sum of scores was used to derive a Breastfeeding (BF) knowledge score (range 0–6) and a Complementary feeding (CF) score (range 0–8).

Child morbidity was measured by maternal recall of symptoms of morbidity (fever, cough/cold and diarrhoea) experienced by the child in the 2 weeks prior to the survey. Child anthropometric data were collected for all children 0–59.9 months using standard methods (Cogill 2003) by trained and standardised field staff. Children's weight and length/height measurements were used to convert into HAZ and weight-for-length z-scores or WHZ according to 2006 WHO child growth standards (WHO 2010). Stunting was defined as HAZ less than −2 and wasting as WHZ less than −2.

Other variables measured

Household hunger was measured using FANTA/USAID's Household Hunger Scale (HHS) (Ballard et al. 2011). Household dietary diversity was measured using FANTA/USAID's Household Dietary Diversity Score (HDDS) (Swindale and Bilinsky 2006). Household social economic status (SES) index was constructed by principal component analysis using several variables such as ownership of house and land, housing

quality, access to services and assets (Vyas and Kumaranayake 2006; Gwatkin et al. 2007). Households were categorised into SES quintiles based on their individual SES index.

Programme exposure

We assessed exposure to the intervention using reported maternal and household participation in RAIN women's groups or other group meetings and delivery. Participation was measured by recall at the endline survey, using questions regarding membership in RAIN women's groups and attendance at RAIN group meetings. Delivery scores were measured, through maternal recall at endline, across three major areas: meeting quality, home visit completion and input receipt. For the Ag-G delivery scores, indicators of meeting quality included regular model farmer attendance and coverage of agriculture- and gender-related topics. Home visit completion included whether the household was visited by SMF, how many times and the duration of each visit. Input receipt was measured as the variety of seed and livestock received. The Ag-G-BCC delivery scores included all the measures described above for the Agriculture score plus regular CHV meeting attendance, coverage of nutrition topics and CHV home visit completion.

Data analysis

The analysis presents the intention-to-treat (ITT) effects (the effect of being randomly assigned to one of the intervention arms regardless of whether the household participated in the RAIN intervention or received any benefits) rather than the treatment effect on treated households (those that participated and received the programme interventions).

Baseline differences between the intervention groups were tested using ANOVA test (for continuous variables) or Chi-square test (for categorical variables). For impact analyses, we derived difference-in-difference (DID) impact estimates using fixed-effects regression models that assessed differences in changes over time between the two intervention groups (Ag-G and Ag-G-BCC) and compared to the control group (Gertler et al. 2011), adjusting for geographic clustering, infant age, gender and variables that were significantly different between groups at baseline (HDDS).

Results

Baseline characteristics

Baseline maternal and household characteristics are presented in Table 1. On average, mothers were 30 years old. A small fraction of these women had never attended school, between 22 and 24 per cent had completed primary school and 64–69 per cent had completed middle school. Most of the respondent women were married (83–86 per cent), and the primary occupation was agriculture for 63–77 per cent of the households. Based on the HHS, less than 10 per cent of households were classified as suffering from either moderate or severe hunger. Most households owned the house they lived in and owned on average eight durable goods and eight productive assets. HDDS, however, was relatively low; the average number of food groups consumed was 6.7–7.6 food groups out of 12. Most maternal and household characteristics were similar among the three groups, except for household dietary diversity, which was lower among the Ag-G-BCC group. Access to tap water was extremely low, with 2.45–3.99 per cent of households having access to tap water. Borewell access was much better at about 60 per cent, as was access to improved toilet facility (64–83%).

Table 1. Selected baseline characteristics among households with children 24–59.9 months by programme group.

	Ag-G-BCC (n = 978)	Ag-G (n = 1025)	Control (n = 1041)
	Per cent/mean (SD)	Per cent/mean (SD)	Per cent/mean (SD)
Age of respondent woman, years	30.46 (8.35)	30.49 (8.48)	30.69 (9.14)
Education of respondent woman			
Never attend school	4.62	5.77	4.09
Primary school	22.15	24.56	21.60
Middle school	66.15	63.80	68.77
High school or higher	7.08	5.87	5.54
Civil status of respondent women			
Married (union)	86.30	82.99	84.25
Living alone (unmarried, widowed, divorced, separated)	13.70	17.01	15.75
Primary occupation of household			
Agriculture	75.72	63.21	76.83
Household hunger category (HHS)[a]			
Little to no hunger (score 0–1)	91.40	92.18	91.01
Moderate hunger (score 2–3)	7.78	5.57	7.83
No hunger (score 4–6)	0.82	2.25	1.16
Household dietary diversity category (HDDS)[b]	6.74 (1.97)***	7.60 (2.17)	7.20 (2.33)
0–4 food groups	10.64***	5.77	12.08
5–6 food groups	42.37	30.21	29.66
7–8 food groups	25.38	28.15	27.05
9–12 food groups	21.60	35.87	31.21
Household assets			
Households that own their dwelling	95.08***	92.17	96.43
Total number of durable goods (mean)	8.39 (6.25)	8.06 (6.47)	8.49 (6.80)
Total number of productive assets (mean)	8.58 (32.97)	8.49 (34.83)	7.40 (4.70)
Household socio-economic status			
First quintile	18.04	23.49	17.89
Second quintile	18.35	17.08	19.26
Third quintile	21.55	22.70	22.19
Fourth quintile	20.52	16.98	20.43
Fifth quintile	21.55	19.74	20.23
Hygiene and sanitation			
Access to tap water	3.99	2.45	3.47
Access to borehole water	62.03	59.10	59.65
Access to improved toilet facility	79.32	64.38	83.08

Values are % or mean (SD). Significant differences: ***$p < 0.001$.
[a]Household hunger was measured using FANTA/USAID's Household Hunger Scale (Ballard et al. 2011).
[b]Household dietary diversity was measured using FANTA/USAID's Household Dietary Diversity Score (Swindale and Bilinsky 2006).

Exposure to the RAIN intervention

Table 2 shows low participation rates in the RAIN project; only 31 per cent of women in the Ag-G group reported being a member of a RAIN women's group and 34 per cent in the Ag-G-BCC group.[3] Most households in the sample had heard of the RAIN project in the two intervention areas. Around a quarter had ever attended a RAIN group meeting, and a very small proportion had attended in the past six months.[4] Date of joining was split evenly over the four rounds of recruitment between 2011 and 2014 in the Ag-G-BCC group, but tailed off slightly in the final years in the Ag-G group.

Table 2. Programme participation.

	Ag-G-BCC (n = 1212)	Ag-G (n = 1244)	Control (n = 1080)
	Per cent/mean (SD)	Per cent/mean (SD)	Per cent/mean (SD)
Mother has heard of the RAIN project	95.63***	83.84	15.57
Mother is a member of a RAIN women's group	34.24***	30.97	0.74
Mother is an SMF (model farmer) for the RAIN project	6.68***	7.07	0.65
Mother ever attended a RAIN group meeting	26.57***	21.95	0.09
Number of RAIN group meetings attended since 2015[a]	4.20 (3.05)	3.96 (2.80)	2.00 (0.00)
Time joined this group[b]			
2010	2.71	3.03	0
2011	27.41	32.66	0
2012	28.61	31.99	–
2013	23.19	17.51	0
2014	13.86	10.77	0
2015	4.22	4.04	0
Households have participated in other RAIN events	22.19	17.60	1.30
Households have seen RAIN posters	27.56	29.04	26.81
Households have heard RAIN radio messages	60.03	57.32	45.64
Households have access to solar drier	8.29	8.78	0

Values are % or mean (SD). Significant differences: ***$p < 0.001$.
Responses are among the entire sample, unless indicated otherwise.
[a]Among people who attended a RAIN group meeting (n = 596).
[b]Among people who is a not an SMF for the RAIN project (n = 630).

Table 3 presents results on maternal perceptions of the quality of programme delivery. An important aspect of exposure is the quality of contact with the SMFs (agriculture) and CHVs (health) who are the frontline workers on the RAIN project. Table 3 shows that SMFs were present at the last RAIN group meeting in most cases, but CHVs were present at fewer than half of those meetings in the Ag-G-BCC group and were present at almost 40 per cent of group meetings in the Ag-G group, suggesting programme leakage between the two intervention arms. Maternal recall suggests that nutrition and health topics were not very well covered in the RAIN meetings in the Ag-G-BCC group and that several of these topics were covered in the Ag-G group as well – again indicating programme leakage. Coverage of agriculture-related topics was slightly better than for health and nutrition topics, but still low, and input receipt was less than 20 per cent, with no differences between the two treatment groups.

Impacts on women's empowerment and time

Table 4 reports baseline and endline means for different measures of women's empowerment and the DID impact estimates. Since the gender component of the intervention was identical across the two intervention arms, we present the impact of the RAIN project for the two intervention groups (Ag-G and Ag-G-BCC) combined.

Significant impacts of the programme were observed for four women's empowerment domains: social capital (DID impact estimate of 17pp), asset access (6pp), financial empowerment (4pp) and agriculture empowerment (6pp). No impacts were seen for decision-making power, spousal relationship, gender equality score and asset selling score. The buying power score went up in both groups, but it was higher in the intervention than control group at baseline, leading to a negative impact of the programme on this domain of empowerment. Similar results on women's empowerment were observed among the subsample of women with children 24–47.9 months.

Table 3. Programme delivery quality (based on maternal recall at endline survey).

	Ag-G-BCC (n = 1212)	Ag-G (n = 1244)
	Per cent/mean (SD)	Per cent/mean (SD)
Meeting quality		
SMF present last meeting[a]	90.37	90.48
CHV present last meeting[a]	45.61	38.21
Topic covered at RAIN meeting[a]		
Nutrition and health		
Breastfeeding	8.39	5.13
Complementary feeding	17.08	14.29
Water, sanitation and hygiene (WASH)	0.62	2.20
Growth monitoring	0.93	1.83
Antenatal care	1.55	1.83
HIV topic	0.00	0.37
Agriculture		
Planning a garden	37.27	38.10
Soil fertility	11.49	9.52
Watering plants	11.18	9.52
Pest management and control	8.70	5.86
Vegetable production	15.22	20.15
Seed preservation	3.11	5.13
Improved goat housing	8.70	6.23
The role of small livestock	12.11	5.13
Goat breeding	9.32	11.36
Crop production	5.28	7.69
Use of solar food dryer	4.97	5.49
Gender training[b]	21.56	21.92
Home visit completion		
Households visited by SMF[a]	53.11	45.59
Number of SMF visits in 2015[c]	2.23 (1.73)	2.68 (2.68)
Duration of SMF visits (minutes)[c]	24.05 (14.38)	25.10 (16.72)
Households visited by CHV in 2015[a]	28.26	21.98
Number of CHV visits in 2015	1.81 (1.74)	3.33 (9.56)
Duration of CHV visits (minutes)[d]	20.61 (17.28)	28.85 (32.28)
Input receipt		
Variety of seeds	15.91**	12.11
Pesticides/fertiliser	1.39	0.80
Tools/cart	0.00	0.09
Cattle/goat/sheep/donkey	18.48*	14.77
Chicken/duck/pigeon	10.49	9.61
Pig	0.20	0.00

Values are % or mean (SD). Significant differences: **$p < 0.01$, *$p < 0.05$.
Responses are among the entire sample, unless indicated otherwise.
[a]Among people who attended a RAIN group meeting (n = 596).
[b]Among people who attended any other RAIN events (n = 488).
[c]Among people who visited by an SMF (n = 295).
[d]Among people who visited by a CHV (n = 294).

Table 5 presents endline results for women's total time spent on different activities the day before the survey. We observe that women in the Ag-G and Ag-G-BCC groups spend 37 min more on agriculture work and 19 min fewer on domestic work (which includes caring for children and cooking and so forth) as compared to women in the control group. Women in the treatment

Table 4. Key domains of women's empowerment by programme group and survey round.

	Baseline (T1)		Endline (T2)				
	Ag-G-BCC + Ag-G	Control	Ag-G-BCC + Ag-G	Control	Ag-G-BCC + Ag-G (T2-T1)	Control (T2-T1)	Difference indifference
All women	(n = 2003)	(n = 1041)	(n = 2456)	(n = 1080)			
Social capital score	0.39***	0.47	0.59***	0.49	0.19***	0.02	0.17***
Decision-making power	0.76	0.74	0.84	0.85	0.09***	0.10***	−0.02
Spouse relationship score	0.61**	0.54	0.61	0.54	0.00	0.00	−0.001
Perception of equality score	0.73	0.71	0.68**	0.64	−0.05***	−0.07***	0.02
Asset access score	0.45	0.48	0.53**	0.50	0.08***	0.02	0.06*
Assess selling score	0.17	0.19	0.14*	0.18	−0.03***	−0.01	−0.03
Buying power score	0.64	0.61	0.76**	0.81	0.12***	0.20***	−0.08*
Financial empowerment score	0.24**	0.29	0.23	0.25	−0.003	−0.04***	0.04*
Agriculture empowerment score	0.18	0.20	0.38	0.34	0.20***	0.14***	0.06*
Mothers with children 24–47.9 months	(n = 1457)	(n = 786)	(n = 1659)	(n = 687)			
Social capital score	0.39***	0.48	0.58***	0.49	0.19***	0.01	0.19***
Decision-making power	0.75	0.73	0.84	0.85	0.09***	0.12***	−0.03
Spouse relationship score	0.61*	0.55	0.61	0.56	−0.01	0.01	−0.02
Perception of equality score	0.72	0.71	0.68*	0.64	−0.05***	−0.06***	0.02
Asset access score	0.44	0.48	0.52**	0.49	0.09***	0.02	0.07**
Assess selling score	0.17	0.18	0.13	0.17	−0.04**	−0.02	−0.02
Buying power score	0.63	0.60	0.76*	0.80	0.13***	0.19***	−0.06
Financial empowerment score	0.24**	0.29	0.23	0.24	−0.004	−0.05***	0.05*
Agriculture empowerment score (0–7)	0.18	0.20	0.38	0.34	0.20***	0.14***	0.07*

Values are mean. Significant differences: ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.
Double difference impact estimates with clustered standard errors comparing 2011 and 2015. Accounts for geographic clustering.

Table 5. Time allocation (hours and minutes) by programme group.

	Endline			
	Ag-G-BCC + Ag-G (n = 2456)		Control (n = 1080)	
Activities	Hours	Minutes	Hours	Minutes
Leisure activities	14	10*	14	35
Agriculture work	3	32**	2	55
Domestic work	4	41*	5	0
Other work	1	10	0	59

Values are mean, Significant differences: **$p < 0.01$, *$p < 0.05$.

groups are also spending a little less time (25 min) in leisure activities as compared to women in the comparison group. These differences in which women in the intervention groups had more agricultural work, coming at the expense of leisure and domestic work including child care, are a potential negative externality of the intervention.

Impacts on maternal knowledge of IYCF practices

Table 6 presents the programme impact on maternal knowledge of breastfeeding and complementary feeding. The results show that breastfeeding knowledge increased on most aspects between baseline and endline for all three groups, and these differences are statistically significant in most cases. DID estimates show that breastfeeding knowledge increased more in the Ag-G-BCC and in the Ag-G groups compared to the control group (individual comparisons with control group) on expressing breastmilk (12.7pp and 12.1pp, respectively) and breastfeeding up to 24 months (14.8pp and 16.3pp) but increased more in the control compared to the Ag-G-BCC and Ag-G groups, respectively, on other topics such as giving colostrum to the child (−6.4pp and −5.30pp) and giving other liquids or foods during the first six months (−13.4pp and −12.4pp). For breastfeeding when the mother is ill, knowledge decreased in all three groups, but more so in the Ag-G-BCC group compared to the control group (−9.9pp). We do not observe any significant differential impact between the two intervention groups on any of the breastfeeding knowledge questions or the total breastfeeding knowledge score.

The knowledge questions for complementary feeding practices focused on the timeliness of introduction of different types of foods. We find that knowledge improved in all three groups for all food types between baseline and endline which is statistically significant. However, knowledge improved significantly more in the Ag-G-BCC group compared to the control group for the timely introduction of nutritious, animal source foods such as meat (28.5pp), fish (14.0pp), eggs (12.0pp) and milk (10.1pp). This was also true for the Ag-G compared to the control group for meat (22.6pp) and milk (13.7pp). Consequently, the overall increases in scores on knowledge related to the timing of introduction of complementary foods were statistically significantly greater in the Ag-G-BCC compared to the control group. There were, however, no statistically significant differential impacts in favour of the Ag-G-BCC compared to the Ag-G group on these questions, which we had hypothesised given the BCC intervention.

Impacts on breastfeeding and complementary feeding practices

Table 7 shows that, although breastfeeding was almost universal in this population, most other IYCF practices were largely suboptimal at baseline. Early initiation of breastfeeding was practised by less than two-thirds of the mothers and was as low as 55 per cent among the Ag-G-BCC group, and exclusive breastfeeding was practised by 72–74 per cent of mothers of children 0–5.9 months. Although most children were reported to have received semi-solid and solid foods at the right age,

Table 6. Knowledge of IYCF (among mothers with children 0–23.9 months of age) by programme group and survey round.

	Baseline (T1)			Endline (T2)						Difference in difference		
	Ag-G-BCC (n = 690)	Ag-G (n = 645)	Control (n = 799)	Ag-G-BCC (n = 634)	Ag-G (n = 560)	Control (T2-T1)	Ag-G-BCC (n = 724)	Ag-G (T2-T1)	Control (T2-T1)	Ag-G-BCC vs control	Ag-G vs control	Ag-G-BCC vs Ag-G
Breastfeeding practices												
Baby should be breastfed immediately after birth	81.57	85.58	80.98	97.01	97.71	97.25	15.44***	12.13***	16.27***	−0.8	−4.1	0.3
Mother should give her baby colostrum	90.43**	90.67	86.11	95.28	96.65	97.38	4.84***	5.99***	11.28***	−6.40*	−5.30*	−1.10
Mother should not give other liquids/foods before her baby is 6 months	60.47**	62.73	53.64	66.46**	69.72	73.00	6.00*	6.99*	19.36***	−13.4*	−12.4*	−1.0
Continuation of BF if the mother is ill	94.91***	94.70	86.97	82.18	84.15	84.16	−12.73***	−10.55***	−2.81	−9.9*	−7.7+	−2.2
Mother should express breastmilk to feed her baby in certain circumstances	6.69***	4.82	13.44	25.35*	22.89	19.42	18.67***	18.07***	5.98**	12.70**	12.1**	0.6
Baby should be breastfed ≥24 months	38.56**	29.92	34.11	42.36***	35.21	23.11	3.80	5.29+	11.00***	14.8*	16.3**	−1.5
Breastfeeding score, mean (SD)	3.73***	3.69	3.55	4.09**	4.06	3.94	0.36***	0.37***	0.39***	−0.04	−0.02	−0.02
(range 0–6)	(0.84)	(0.86)	(0.98)	(0.87)	(0.84)	(0.82)	(0.05)	(0.05)	(0.05)			
Timeliness of introduction CF foods												
Starchy foods	90.43**	85.12	81.73	97.80*	96.83	93.66	7.36***	11.71***	11.94***	−4.6+	−0.2	−4.4
Legumes	85.07**	84.65	77.22	96.85**	94.37	87.88	11.78***	9.72***	10.66***	1.1	−0.9	2.1
Green leafy vegetables	76.96**	78.91	68.96	94.65***	91.37	81.68	17.69***	12.46***	12.72***	5.0	−0.3	5.2
Orange fleshed vegetables/fruits	76.38**	75.35	67.96	94.02**	86.97	83.47	17.64***	11.62***	15.51***	2.1	−3.9	6.0
Meat	29.71	29.61	33.79	74.80***	68.84	50.41	45.09***	39.23***	16.62***	28.5***	22.6**	5.9
Fish	53.33	56.43	50.19	80.00**	73.77	62.81	26.67***	17.33***	12.62***	14.0*	4.7	9.3
Eggs	82.75	81.86	78.97	95.43***	89.96	79.61	12.68***	8.10***	0.64	12.0***	7.5+	4.6
Milk	81.30*	77.52	75.22	95.43***	95.25	79.20	14.13***	17.73***	3.98	10.1**	13.7***	−3.6
CF score, mean (SD)	5.76***	5.69	5.34	7.29***	6.97	6.19	1.53***	1.28***	0.85***	0.68**	0.43	0.25
(range 0–8)	(1.98)	(2.12)	(2.22)	(1.36)	(1.76)	(2.00)	(0.09)	(0.11)	(0.11)			

Significant differences: ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$, +$p < 0.10$. Double difference impact estimates with clustered standard errors comparing 2011 and 2015. Accounts for geographic clustering.

Table 7. IYCF practices among children 0–23.9 months of age by programme group and survey round.

	Baseline (T1)			Endline (T2)						Difference in difference		
Impact indicators	Ag-G-BCC (n = 690)	Ag-G (n = 645)	Control (n = 799)	Ag-G-BCC (n = 634)	Ag-G (n = 560)	Control (n = 724)	Ag-G-BCC (T2-T1)	Ag-G (T2-T1)	Control (T2-T1)	Ag-G-BCC vs control	Ag-G vs control	Ag-G-BCC vs Ag-G
Core indicators												
Early initiation of breastfeeding[a]	54.70**	62.62	60.95	85.83	86.24	86.09	31.12***	23.63***	25.14***	5.70	−1.80	7.50
Exclusive breastfeeding[b]	74.06	74.18	72.28	81.59	82.39	78.32	7.54	8.21	6.04	1.30	8.10	−7.00
Continued breastfeeding at 1 year[c]	95.12	97.58	91.20	96.30	95.06	95.10	1.17	−2.52	3.90	−2.60	−6.70	3.80
Introduction of solid, semi-solid or soft food[d]	89.53	93.33	91.30	94.57	93.41	97.98	5.03	0.07	6.68*	−2.00	6.60	4.40
Minimum diet diversity	29.55	33.26	31.58	42.03	39.90	35.54	12.48***	6.64*	3.96	8.30	3.50	4.70
Minimum meal frequency[e]	48.27*	58.19	51.92	58.89	59.85	58.23	10.62**	1.66	6.32*	3.90	−8.10	11.60*
Minimum acceptable diet[f]	20.34	22.61	22.92	30.25	26.93	26.91	9.91***	4.32	3.99	5.90	0.40	5.50
Consumption of iron-rich food[g]	53.53	59.57	53.91	40.51	46.63	39.36	−13.02***	−12.93***	−14.55***	1.40	3.00	−1.90

Significant differences: ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.
[a]Child aged 0–23.9 months.
[b]Child aged 0–5.9 months.
[c]Child aged 12–15.9 months.
[d]Child aged 6–8.9 months.
[e]Minimum is defined as two times for breastfed infants 6–8 months; three times for breastfed children 9–23.9 months; four times for non-breastfed children 6–23.9 months. 'Meals' include both meals and snacks and frequency is based on mother's report.
[f]Acceptable diet is defined as who had at least the minimum dietary diversity and the minimum meal frequency during the previous day.
[g]Iron-rich or iron-fortified foods include flesh foods, commercially fortified foods especially designed for infants and young children that contain iron or foods fortified in the home with a micronutrient powder containing iron.

minimum dietary diversity was met only for 30 per cent per cent of the children in our sample, and a little over one-half of the children consumed any iron-rich foods at baseline. Only about one-fifth of the children achieved the minimum acceptable diet.

As observed for maternal knowledge, most IYCF practices improved between baseline and endline (except the consumption of iron-rich foods) in all three groups. Some of these differences are statistically significant. In the Ag-G-BCC group, early initiation of breastfeeding, percentage of children with minimum dietary diversity, minimum meal frequency and minimum acceptable diets increased between baseline and endline. At the same time, consumption of iron-rich foods declined in this group. Apart from improvements in early initiation of breastfeeding and decline in consumption of iron-rich foods, there were no other significant changes over time in the Ag-G and control groups.

When comparing over time across groups, there were no statistically significant differential impacts on any practice between either the Ag-G-BCC or the Ag-G and the control group. Comparing improvements over time between the Ag-G-BCC and the Ag-G groups, however, we find that most are positive (in favour of the Ag-G-BCC group), except for exclusive breastfeeding and consumption of iron-rich foods, and statistically significant for minimum meal frequency (11.6pp), indicating the added value of the nutrition BCC to the agriculture and gender intervention only.

Impacts on children's nutrition outcomes

At baseline, stunting affected approximately 45 per cent of children 24–47.9 months in our sample, and the average HAZ was ~1.8 (Table 8). Stunting dropped markedly between baseline and endline, by 13pp in the Ag-G-BCC group, 15pp in the Ag-G group and 18pp in the control group, leading to endline rates of stunting as low as 32, 34 and 30 per cent, respectively. HAZ also improved significantly over the study period in the three groups (by 0.72, 0.57 and 0.89 *z*-scores for Ag-G-BCC, Ag-G and control groups, respectively). However, there were no statistically significant differentials in changes between baseline and endline between the groups for either stunting or HAZ.

Wasting results showed a different picture, with wasting rates being low at baseline (3.39%, 1.79% and 2.19% for the Ag-G-BCC, Ag-G and control groups, respectively) and going up dramatically over the study period to reach 6.88, 5.29 and 9.12 per cent, respectively. As expected, increases in wasting were accompanied by drops in WHZ (except in the Ag-G group), which were statistically significant for the control group. No statistically significant differential impacts in changes between baseline and endline between groups were found for wasting, but there was a statistically significant higher increase in WHZ among the Ag-G compared to the control group (+0.38).

Table 9 presents results on child morbidity. At baseline, the reported prevalence of morbidity symptoms was moderately high; it ranged from 23 to 26 per cent for cough/cold, 17 to 19 per cent for fever and 11 to 14 per cent for diarrhoea. These rates declined significantly across all three groups between baseline and endline (except for cough/cold in the Ag-G group). Rates of decline were statistically significantly greater among the Ag-G-BCC compared to the Ag-G group for cough/cold (−10.8pp) and diarrhoea (−6.7pp). For cough, the decline prevalence between baseline and endline was statistically significantly greater for the Ag-G compared to the control group.

Discussion

The RAIN project benefited women and children in many ways. It improved several aspects of women's empowerment and IYCF knowledge, prevented deterioration in WHZ and reduced child diarrhoea and cough/cold symptoms. RAIN, however, had limited impacts on IYCF practices and no impact on child stunting.

Table 8. Anthropometric indicators among children 24–47.9 months of age by programme group and survey round.

	Baseline (T1)			Endline (T2)						Difference in difference		
Impact indicators	Ag-G-BCC (n = 698)	Ag-G (n = 759)	Control (n = 786)	Ag-G-BCC (n = 809)	Ag-G (n = 850)	Control (n = 687)	Ag-G-BCC (T2-T1)	Ag-G (T2-T1)	Control (T2-T1)	Ag-G-BCC vs control	Ag-G vs control	Ag-G-BCC vs Ag-G
HAZ, mean (SD)	−1.79 (1.45)	−1.83 (1.43)	−1.88 (1.56)	−1.08* (1.97)	−1.26 (1.84)	−0.99 (1.82)	0.72***	0.57***	0.89***	−0.18	−0.33	0.15
WHZ, mean (SD)	0.50 (1.36)	0.39 (1.14)	0.46 (1.25)	0.41*** (1.61)	0.45 (1.48)	0.14 (1.62)	−0.09	0.07	−0.32***	0.22	0.38*	−0.16
Stunting, %	45.21	49.59	48.08	31.99	34.25	30.00	−13.22***	−15.34***	−18.08***	4.80	2.70	1.90
Wasting, %	3.39	1.79	2.19	6.88*	5.29	9.12	3.50**	3.50***	6.93***	−3.50	−3.40	−0.00

Significant differences: ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.
[a]Double difference impact estimates with clustered standard errors comparing 2011 and 2015. Accounts for geographic clustering only.

Table 9. Child morbidity by programme group and survey round among children 24–47.9 months.

	Baseline (T1)			Endline (T2)						Difference in difference		
Indicators	Ag-G-BCC (n = 698)	Ag-G (n = 759)	Control (n = 786)	Ag-G-BCC (n = 809)	Ag-G (n = 850)	Control (n = 687)	Ag-G-BCC (T2-T1)	Ag-G (T2-T1)	Control (T2-T1)	Ag-G-BCC vs control	Ag-G vs control	Ag-G-BCC vs Ag-G
Fever	17.91	18.60	17.45	5.81	10.94	6.56	−12.10***	−7.66***	−10.89***	−1.2	3.3	−4.4
Cough/cold	24.79	23.12	26.40	12.75	21.88	15.43	−12.04***	−1.24	−10.97***	−1.1	9.8*	−10.8**
Diarrhoea	14.18	12.40	11.25	4.20	9.07	4.37	−9.98***	−3.33*	−6.88***	−3.3	3.5	−6.7*

Significant differences: ***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.
[a]Double difference impact estimates with clustered standard errors comparing 2010 and 2014. Accounts for geographic clustering.

We discuss our findings in light of the theory of change described earlier. In the RAIN project, the SMFs were identified and the women's groups created to deliver the gender and agricultural trainings and farming inputs. Results from Rosenberg et al. (2017) show a significant impact of the RAIN project on food production diversity measured by the number of agricultural activities carried out and the number of food groups produced. They also find a significantly positive impact of the intervention on productive assets such as agricultural tools which can potentially be attributed to increased incomes from sale of food (Rosenberg et al. 2017). In this paper, we show that RAIN led to significant increases in women's social capital, access to and control over assets and financial and agricultural decision-making power. There were no impacts, however, on decision-making power for non-agricultural topics (for example, spending on child education, health and feeding), spousal relationship, gender equality score and asset selling score. Engagement in agricultural activities in the two RAIN intervention groups also appeared to constrain women's time; they spent more time on agricultural work and less time on domestic and child caregiving activities, as well as leisure activities compared to women in the control group. Overall, the RAIN project made some inroads into improving some aspects of agricultural diversity and women's empowerment. As cautioned by many, however, in order to achieve greater impacts and prevent the potentially negative effects of agriculture projects on women's time, measures should be put in place to support women in their multiple roles as caregivers and key players in securing household income and food security (Johnston et al. 2015; Komatsu, Hazel Jean, and Theis 2015; Stevano 2016).

Although the RAIN inputs provided the expected benefits for some of the hypothesised processes and outputs, namely in the areas of production diversity and women's empowerment, these did not translate into the desired outcomes of improving household (Rosenberg et al. 2017) or child dietary diversity (our results). For the child, the lack of impact on Dietary Diversity (DD) is supported by the lack of impact of the programme on maternal knowledge of IYCF practices. Additionally, Rosenberg et al. (2017) notes that the increased production diversity does not persist throughout the year and thus may be insufficient to improve diets throughout the year. There is evidence that the RAIN project led to improved access to foods that are storable such as legume and nuts but not for perishable foods – which underscores the importance of linking to food markets. These results show that increased production diversity along with improved women's empowerment may not be sufficient to improve diets within the household and highlight the fact that increasing knowledge, information and linking to markets are likely to be needed in most contexts in order to achieve improvements in practice.

Maternal knowledge of optimal IYCF practices improved in all three groups over the course of the study, suggesting that there were some ongoing efforts to improve IYCF knowledge and practices in the country. The lack of differential impacts between groups that received and those that did not receive the RAIN BCC intervention is likely due to some of the participation and implementation challenges encountered by the programme. However, we do find impacts of the BCC intervention on the overall complementary feeding knowledge score in the Ag-G-BCC compared to the control group, which suggests that some knowledge transfer was achieved. Maternal IYCF practices also improved in all three groups over time, and minimum meal frequency was the only practice that was significantly greater at endline in the Ag-G-BCC group compared to the Ag-G group.

Consistent with the maternal IYCF knowledge and practices, changes in stunting and HAZ also improved between baseline and endline in all three groups. For stunting and HAZ, the changes were dramatic: reductions in stunting were in the order of 13–18pp (with the larger reduction found in the control group) and increases in HAZ ranged from 0.57 to 0.89 *z*-scores (again with the larger increase in the control group). Not surprisingly, this resulted in a lack of differential impact of the programme on stunting or HAZ. Wasting, on the other hand, increased during the study period (by more than twofold in the Ag-G-BCC, threefold in the Ag-G group and fourfold in the control group). Relatedly, WHZ dropped in all three groups, and the magnitude of the drop was statistically significantly lower in the Ag-G compared to the control group. Overall, it appears that the RAIN

programme had a small protective effect on WHZ, but no impact on stunting improvements above and beyond the large positive secular trend.

The magnitude of improvements in stunting over the study period, which brought the average stunting rate in our sample to about 32.2 per cent, is difficult to explain. Zambia has been praised for its rapid improvements in child undernutrition in the past 15 years, showing declines from 53 per cent stunting in under-five children in 2002 to 40 per cent in 2014, a rate of approximately 1pp reduction per year (Central Statistical Office, Ministry of Health, Tropical Diseases Research Centre, University of Zambia, and Macro International Inc 2014; Harris et al. 2016a). These improvements were accompanied by steady decreases in maternal and child under-five mortality rates and rapid increases in exclusive breastfeeding among children 0–6 months of age (from 40% in 2002 to 74% in 2013). Rapid (though unequal) economic growth and improvements in public health services including vaccination, vitamin A supplementation and mosquito net distribution to prevent malaria have been found to be important drivers of the positive trends in child undernutrition observed in Zambia since 2002 (Harris et al. 2016a).

These analyses provide useful pointers for understanding the positive trends in stunting reduction in Zambia, but they fall short of explaining the unusually large magnitude of stunting reductions observed in our study areas. It is possible that our study area benefited from unusually rapid positive changes in some of the key drivers of stunting reduction in the country. Some evidence of this includes the large improvements in IYCF knowledge and practices and the significant decline in morbidity due to diarrhoea and cough/cold in all three groups over the study period, both of which could have contributed to stunting reduction (Checkley et al. 2008; Torres et al. 2000). These findings are also supported by the generally improved sanitation and hygiene situation in the area, with households having greater access to tap and borehole water and to improved toilet facilities. We are also aware of three new vaccines that were introduced in the region between 2012 and 2014, which targeted rotavirus and respiratory infections. The District Nutrition Coordination Committee, which was constituted to improve nutrition in the district at the same time as RAIN started and supported through the project, grew stronger over the four years of the study, creating an impetus for strengthening nutrition-focused work in the district. Nutrition also became more prominent at the national level in recent years (Harris et al. 2016a), and CHVs in all areas were trained on government IYCF guidelines and materials (which are comprehensive and locally relevant). Evidence of some of these positive trends in our study area come from our findings that mothers were much more likely to report receiving nutrition counselling during pregnancy and counselling on breastfeeding at endline, compared to baseline, across all study arms (results not shown). It is possible that a combination of these factors has contributed to a rapid decline in stunting in the study area, but further work is needed to understand this change.

An important factor leading to the lack of differential impact of RAIN may have been that the programme did not include components that addressed other constraints to linear growth such as high rates of malaria or other infections or poor growth trajectories due to intra-uterine growth retardation (Bhutta et al. 2013).

Wasting, a secondary outcome of the study, had stagnated at around 6 per cent in the country over the past two decades. At baseline, wasting in our study area (2.5%) was lower than national average (6%) (Central Statistical Office, Ministry of Health, Tropical Diseases Research Centre, University of Zambia, and Macro International Inc 2014), but it increased over the study period to higher than national average especially in the control group, where it reached 9 per cent. The Ag-G intervention had a protective effect on WHZ, but the overall deterioration in WHZ and wasting in our sample over time is difficult to interpret, especially given the large reductions in diarrhoeal morbidity (which is strongly associated with wasting; Checkley et al. 2008; Torres et al. 2000) observed in all three groups and more so in the group that was exposed to the BCC intervention.

Low participation rate in the RAIN project is yet another important consideration, which dilutes the ITT estimates on all outcomes. Given the low rates of participation, sub-analyses of the sample

who participated in the programme is underpowered and was therefore not conducted. We explored factors that may have led to this low participation. Our process evaluation carried out in 2014 highlighted several of the constraints voiced by women as reasons for not joining the RAIN groups, many of which revolved around lack of time and the large distances women had to travel to reach group meetings. Some noted not being able to complete household chores if they attended the meetings, others said that they could not find someone to care for their children while they worked (or attended a group meeting) and yet others found it difficult to 'fit everything in'. Programme monitoring data also showed that attendance dropped especially during the rainy season, when no inputs were distributed and travel became especially hard. It is likely that these issues limited participation in the programme, both in terms of enrolment and attendance.

In addition to low participation, our endline survey also highlighted some programme implementation constraints that may have affected its performance and effectiveness. Home visits by the agriculture (SMFs) and health (CHVs) volunteers, a critical component of the intervention, were not implemented as planned – only about half of the households that ever attended a RAIN group meeting reported having been visited by an SMF and about a quarter were visited by a CHV. The process evaluation highlighted that the SMFs, a position created specifically for the RAIN project, were incentivised (through provision of bicycles and/or agricultural inputs) for their role. By contrast, the CHV positions, which already existed in the community (as part of the primary healthcare system), were not provided any incentives until after 2014. In addition, CHVs serviced the entire community, whereas SMFs were working specifically with RAIN groups. These issues combined with the fact that approximately 20 per cent of mothers in the Ag-G group reported being visited by CHV – suggesting some potential leakage of the BCC intervention to that group – may explain why overall there was no evidence of an additional benefit of including a BCC component to the Ag-G intervention.

Our study had several strengths, including the use of a randomised, well-powered, rigorous evaluation design and the assessment of impact over a period of 4 years among children who were exposed to the programme during their first two years of life (the period of greatest potential to benefit from nutrition interventions). The strength of our evaluation design contrasts with many prior studies that also showed a lack of impact on child stunting, but whose design flaws prevented a firm conclusion of evidence of lack of impact or inability to detect impact due to poor and underpowered design (Girard et al. 2012; Masset et al. 2012; Ruel, Alderman, and Maternal 2013). Our study's documented lack of impact on stunting is backed up by a strong design, which makes the results credible. In addition, our analysis included assessment of impacts on several intermediary outcomes along the hypothesised programme impact pathways including women's empowerment, maternal knowledge and practices and child morbidity, which supports the plausibility of our findings. Our companion study also showed that the programme had impacts on other outcomes along the impact pathways, including agricultural production, household access to greater diversity of foods and maternal and child diversity, all of which are important drivers of nutritional change (Rosenberg et al. 2017).

Our study also has some limitations. First, although we used a randomised design with a control group, and study arms were balanced at baseline on observed characteristics measured in the surveys, there may still be other aspects which we failed to measure that can lead to significant differences across the arms over time. For example, the areas exposed to the Ag-G programme are closer to roads (along the main Lusaka road from Mumbwa) and are reported to have on average more medium-scale farmers than other wards. These areas may therefore be easier to reach for government agriculture programmes; have better access to markets; and have generally richer farmers, all aspects that were not captured in the study. Second, the metrics available to measure such a complex concept as women's empowerment are still limited, which means that our instruments may not have captured some aspects of the broad concept which differ between households. Metrics to assess diet were also limited to increases in food groups consumed and would miss increases within food groups that might also be relevant to health and nutrition. Third,

despite the four-year duration of the project, the long start-up times required for agricultural projects and the lag time between start up and harvest of sufficient food to significantly increase household food access means that actual exposure of households, women and children to the full programme may have been much shorter than 4 years. A similar type of programme implemented over a two-year period in Burkina Faso documented that it actually took a minimum of 8 months before the BCC intervention was fully implemented and the households started to harvest vegetables from their home garden (Olney et al. 2016; Olney et al. 2015).

Lessons learned and looking forward

There are important lessons that can be drawn from this study for future programmes and research that links agriculture interventions with changes in gender norms, nutrition behaviours and child nutritional status. First, agriculture projects that tie in nutrition BCC and gender sensitisation are complex and should be tailored to the local context (Darrouzet-Nardi et al. 2016; Herforth and Ballard 2016). Investments should be made upfront in careful planning and design of the intervention package based on extensive consultations with communities and the use of action research to agree on hypothesised pathways of impact and to develop a solid understanding of potential constraints to participation and adoption of recommended behaviours. Evaluation timeline should long enough for the programme to be properly established and for beneficiaries to the intended duration and intensity of exposure before the impacts are assessed. Second, a strong monitoring system, possibly complemented by targeted implementation research, should be put in place to regularly track and monitor performance indicators and ensure that the intervention is implemented as planned, is reaching its targeted beneficiaries and is used by beneficiaries who participate. The system should be flexible and responsive and include rapid feedback mechanisms to ensure that corrective actions are taken when implementation, participation or utilisation constraints are identified. Third, carefully designed rigorous evaluations using appropriate metrics and complemented by impact pathway analyses and implementation science research are still needed to continue to build a credible and plausible evidence based on how agriculture can best contribute to strengthening gender equity and women's empowerment and support sustained improvements in maternal and child health and nutrition. Many research gaps still remain regarding what are the best and most cost-effective combinations and packages of nutrition-specific and nutrition-sensitive interventions and what are the most effective platforms to deliver them (Ruel, Quisumbing, and Balagamwala 2017). Agriculture is certainly one of the key platforms that should continue to be explored and leveraged, given that rural small farmer households host a large share of the maternal and child undernutrition burden, and agriculture is unequivocally a main source of income and food for most of the world's poor.

Notes

1. For more details on the randomisation, please refer to **Appendix A1**.
2. For more details on the power calculations, please refer to **Appendix A1**.
3. This survey sampled only households where there was a child under age 5; therefore, respondents to the survey would have been eligible to join RAIN. We ask about current participation of any woman in the household in RAIN.
4. The survey was undertaken between July and August 2015, and respondents were asked about meetings since January 2015.

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Appendix A1: Randomisation and sample size estimation

Randomisation

Randomisation was done at the level of the ward (an administrative unit smaller than the district) and then at cluster level. Three ward pairs (six total wards) were available to be included in the study. One ward pair was randomly selected to act as the control area (Chisalu & Kapyanga wards) and two ward pairs (Shichanzu & Nalubanda wards and Choma & Milandu wards) to be intervention area. Using the Zambia Central Statistics Office (CSO) 2010 household census, a total of 15 geographically defined census supervisory areas were taken as clusters in the control ward pair and 26 clusters between the two intervention ward pairs. The 26 clusters in the intervention ward pairs were then further randomised to the two RAIN interventions using simple random lottery process, resulting in 13 clusters for the 'Ag-G' areas and 13 clusters for the 'Ag-G-BCC' areas. Figure A1 shows the randomisation process and the sample sizes for households and children of different ages.

Sample size estimations

Sample size calculations were carried out to detect differences in changes between baseline and endline between any intervention groups in the primary outcome of interest (stunting) among children 24–59.9 months of age. We estimated that a total sample of 3000 infants (1000 per group) was sufficient to detect a difference in changes between baseline and endline between groups of at least 8 percentage points (pp). The estimation used alpha of 0.05, power of 0.80 and intra-class correlation of 0.01 (estimated from previous national surveys), assuming a baseline stunting prevalence of 53 per cent (Central Statistical Office, Ministry of Health, Tropical Diseases Research Centre, University of Zambia, and Macro International Inc 2009). Prior to conducting the endline survey, we re-verified our detectable effect sizes based on the original sample size and baseline data. At endline, we oversampled the two RAIN interventions arms, by approximately 20 per cent,

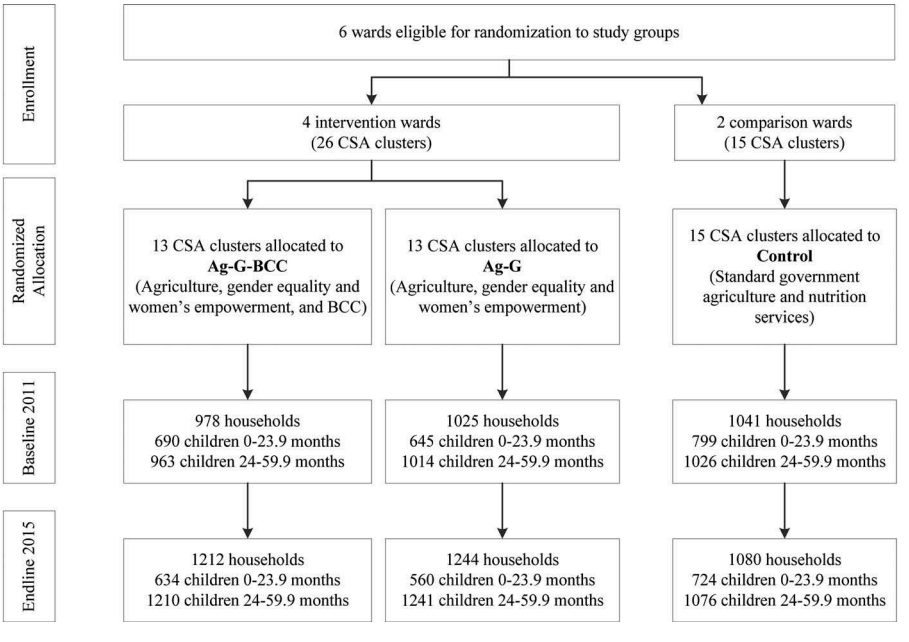

Figure A1. Trial profile

to account for potential limited intervention exposure at the household level. To capture impacts of the RAIN project on key IYCF indicators, children between 0 and 23 months of age (1536 at baseline and 1332 at endline) living in the same household with children 24–59.9 months were also sampled. Data were collected from an actual sample of 3003 children at baseline and 3527 children at endline.

Given the 4-year duration of the RAIN project, children between 24 and 48 months of age at endline had the highest probability of having been exposed to the programme for the whole first two years of their life and thus had the greatest potential to benefit from the intervention. For this reason, we restricted the analysis of impacts on stunting to the subsample of children 24–48 months of age (2243 children at baseline and 2346 at endline). Power calculations were redone on this smaller sample size yielding a detectable difference of 7pp in stunting between baseline and endline between study groups (Table A1).

Table A1 Estimated detectable difference for outcome variables based on baseline data.

Outcomes	Age group (months)	Baseline mean	Baseline SD	Average cluster size	Number of clusters/arm	Sample size (total)	ICC	Detectable difference
HAZ	24–47.9	−1.83	1.48	18	43	2322	0.033	0.21
Stunting	24–47.9	0.48		18	43	2322	0.027	0.07
Women empowerment (total score)	24–59.9	0.19	0.23	23	43	3000	0.056	0.03
Exclusive breastfeeding	0–5.9	0.73		5	43	645	0.008	0.11
Dietary diversity	6–23.9	0.32		10	43	1290	0.107	0.09
Breastfeeding knowledge	0–23.9	3.65	0.91	16	43	2064	0.106	0.14
Complementary feeding knowledge	0–23.9	5.58	2.12	16	43	2064	0.053	0.34

Significance level and power for all the above calculations were 5% and 80%, respectively.

Table A2 Questions used to construct women's empowerment variables.

Social capital score	Do you have somebody who could help you when you need or when you have the following problems?
	1. Accommodation for several nights
	2. Lend you some money (other than your husband)
	3. Give you food when you don't have enough at home (other than husband)
	4. To talk to when you have a problem
	Do you usually meet with other women in your community to discuss any of the following?
	1. Problems of the community?
	2. Education problems?
	3. Health problems?
	4. Problems of women?
	5. To receive information on health and nutrition?
Decision-making power	Which family member decides most of the time about the following things?
	1. Buying important things for the family?
	2. What food is prepared every day?
	3. If you have to work to earn money?
	4. Visiting other family members, friends or relatives?
	5. Seeing a doctor or visiting a dispensary when you are pregnant?
	6. Use of family planning methods?
	7. Sending your child/children to school?
	8. What to do when a child is ill?
	9. How to make children listen or obey?
	10. Having another child or not?
	11. Whether or not you breastfeed the child and when to wean the child?
	12. What and how to feed the infant in his/her first year of life?

(*Continued*)

Table A2 (Continued).

Spouse relationship score	Do you often, sometimes, never talk with your partner or husband about the following subjects:
	1. Your work activities/agricultural activities?
	2. What happens at home?
	3. Your expenditures?
	4. What happens in your community or area?
	5. Your child's health?
	6. Your own health?
	7. Child feeding?
	8. Family planning?
Perception of equality score	Please tell me if you agree or not with each of the following declarations.
	There are people who say:
	1. In a household, the man should take the important decisions.
	2. If the woman works outside home, her husband or partner should help her with the daily housework.
	3. A husband should not let his wife work outside home, even if she would like to do it.
	4. A woman has the right to express her opinion if she does not agree with what the husband or partner says.
	5. A woman must accept that her husband or partner beats her in order to keep the family together.
	6. It is better to send a son to school than a daughter.
Asset access score	Please tell me if you possess alone or together with somebody else one of the following things:
	1. Land?
	2. This house or the house where you usually live?
	3. Another house?
	4. Animals like cows, goats, pigs?
	5. Small animals or poultry, like rabbits, ducks, chickens?
	6. Jewellery?
	7. Motorbike/bicycle?

(*Continued*)

Table A2 (Continued).

Assess selling score	If you have a problem, would you be able to sell one of these possessions without the authorisation of somebody else?
	1. Land?
	2. This house or the house where you usually live?
	3. Another house?
	4. Animals like cows, goats, pigs?
	5. Small animals or poultry, like rabbits, ducks, chickens?
	6. Jewellery?
	7. Motorbike/bicycle?
Buying power score	Can you decide on your own, without consulting anyone, to buy the following things?
	1. Small amounts of food like rice, vegetables and beans?
	2. Bigger amounts of food like a bag of maize or rice?
	3. Clothes for yourself?
	4. Medicine for yourself?
	5. Toilet articles for yourself like soap, toothpaste?
	6. Clothes for the children?
	7. Medicine for the children?
	8. Special foods for your children?
	For each of the following things purchased in your family, please indicate who usually decides what to buy.
	1. Maize meal, rice, legumes, pulses and so forth
	2. Meat, fish, poultry and so forth.
	3. Fruits and vegetables
	4. Packaged products (breads, snacks and so forth)
	5. Cooking oil
	6. Special foods for child
	7. Other food
	8. Milk/soured milk
	9. Medicines

(*Continued*)

Table A2 (Continued).

Financial empowerment score	1. Do you have your own money that you can use whenever you want to use it?			
	2. Do you know of projects for women in this area that lend money so that a woman can start a business or extend the existing business?			
	3. Have you (respondent) benefitted from a loan, either in cash or in kind, to start a business or to extend the existing business (for example, YWCA, Women for Change, FINCA, FAWEZA, CETZAM, Micro Bankers, Women's Empowerment)?			
Agriculture empowerment score		**Field Crop codes**		
	1. Land decision: Who decides what to grow on the land?	1 = Maize	10 = Virginia tobacco	18 = Cassava
	2. Field crop decision: Who was in charge of deciding what to do with the foods produced […]?	2 = Sorghum	11 = Burley tobacco	19 = Kenaf
	3. Vegetables and fruits decision: Who was in charge of deciding what to do with the foods produced […]?	3 = Finger millet	12 = Mixed beans	20 = Cashew nut
	4. Field crop money: Who was in charge of the money from the sale of […]?	4 = Pearl millet/ bulrush	13 = Bambara nuts	21 = Paprika
	5. Vegetables and fruits money: Who was in charge of the money from the sale of […]?	5 = Rice	14 = Cowpeas	22 = Wheat
	6. Animal: Who was in charge of the money from the sale of […]?	6 = Groundnuts	15 = Velvet beans	23 = Sugar cane
	7. Animal products: Who was in charge of the money from the sale of […]?	7 = Soybeans	16 = Coffee	24 = Sunflower
		8 = Seed cotton	17 = Sweet potatoes	98 = Other (specify)
		9 = Irish potato		

(*Continued*)

Table A2 (Continued).

Vegetables		**Fruits**
1 = Cabbage	10 = Onion	17 = Avocado
2 = Carrot	11 = Sweet pepper	18 = Bananas
3 = Chilli	12 = Cleome/ Luyuni	19 = Guava
4 = Fresh maize	13 = Rape	20 = Lemon
5 = Cucumber	14 = Tomato	21 = Mangoes
6 = Egg Plant	15 = Pumpkin	22 = Masuku
7 = Impwa	16 = Other (specify)	23 = Oranges/ tangerines
8 = Green Leaves		24 = Papaya
9 = Okra		25 = Water melon
		98 = Other (specify)

Animals	**Animal products**
Beehives	Animal meat/ offal
Cattle	Poultry meat/ offal
Chicken	Milk and milk prod.
Turkey	Eggs
Guinea fowl/ pigeons	Honey
Duck	Hide/Leather/ Wool
Goat/sheep	Other (Specify)
Donkey/mule/ horse	
Pig	
Rabbit	
Fish (aquaculture)	
Other (Specify)	

Table A3 Questions used to construct knowledge variables.

Knowledge of breastfeeding	
How long after birth should a baby start breastfeeding?	Immediately . . . . . .1 Less than 1 h after delivery . . . . . .2 Some hours later but less than 24 h. . . . .3 1 day later . . . . . .4 More than 1 day later . . . . . .5 Do not think baby should be breastfed . .6 Don't know 88
What should a mother do with the 'first milk' or colostrum?	Throw it away and start breastfeeding when the real milk comes in . . . . . .1 Give it to her baby by breastfeeding soon after birth . . . . . .2 Other (Specify): _____3 Don't know 88
Do you think a mother should stop breastfeeding her child if the mother becomes ill and continue after she becomes better?	Yes . . . . . .1 No . . . . . .2 Don't know 88
Do you think a mother should express breastmilk and then feed this to her baby in certain circumstances?	Yes . . . . . .1 No . . . . . .2 Don't know 88
At what age should a baby stop breastfeeding?	Months
If a mother thinks her baby is not getting enough breast milk, what should she do? (Multiple response possible – do not read list, allow respondent to answer) Up to three responses possible	Breastfeed more often/more frequently . .1 Give other (specify) liquids/foods . . . . . .2 Mother needs to drink more water. . . . . .3 Mother needs to eat more food . . . . . .4 Drink Chibuku . . . . . .5 Bath in herbs. . . . . .6 Other (Specify): . . . . . .7 Don't know 88
Knowledge on timeliness of introduction CF foods	
When can you start giving a young child the following foods?	< 1 Month …… 0
Nshima or other starchy foods like cassava, rice and so forth.	1 Month 1
Legume: beans, lentils, peas	2 Months 2
Green leafy vegetables like spinach, bondwe, pumpkins leaves and so forth.	3 Months 3
Orange, yellow or red-fleshed vegetables such as pumpkin, orange-red-flesh sweet potatoes, carrots	4 Months 4
Meat such as beef, goat, pork	5 Months 5
Fish (small) such as Kapenta, Tutaka	6 Months 6
Eggs (chicken, duck and so forth)	7 Months 7
Milk (cow, goat, sour milk or powdered)	8 Months 8
	9 Months 9
	10 Months. 10
	11 Months. 11
	12 Months. 12
	More than 12 months …… 13
	Don't know/no the answer. 88