

Evaluating interventions to improve child nutrition in Eastern Democratic Republic of Congo

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Abstract

Objective: The prevention of malnutrition in children under two approach (PM2A), women's empowerment and agricultural interventions have not been widely evaluated in relation to child diet and nutrition outcomes. The present study evaluated the effectiveness of PM2A, women's empowerment groups (WEG), farmer field schools (FFS) and farmer-to-farmer training (F2F).

Design: Community-matched quasi-experimental design; outcome measures included children's dietary diversity, stunting and underweight.

Setting: Communities in South Kivu, Democratic Republic of the Congo.

Participants: A total of 1312 children from 1113 households.

Results: Achievement of minimum dietary diversity ranged from 22.9 to 39.7% and was significantly greater in the PM2A and FFS groups ($P < 0.05$ for both comparisons). Fewer than 7.6 and 5.8% of children in any group met minimum meal frequency and acceptable diet targets; only the PM2A group differed significantly from controls ($P < 0.05$ for both comparisons). The endline stunting prevalence ranged from 54.7% (PM2A) to 69.1% (F2F) and underweight prevalence from 22.3% (FFS) to 34.4% (F2F). No significant differences were found between intervention groups and controls for nutrition measures; however, lower prevalences of stunting (PM2A, -4%) and underweight (PM2A and FFS, -7%) suggest potential impact on nutrition outcomes.

Conclusions: Children in the PM2A and FFS groups had better child diet measures and nutrition outcomes with the best results among PM2A beneficiaries. Interventions that address multiple aspects nutrition education, health, ration provision and income generation may be more effective in improving child diet and nutrition in resource-poor settings than stand-alone approaches.

Keywords
Child nutrition
Dietary diversity
Stunting
Underweight
Democratic Republic of the Congo

Globally, maternal and child undernutrition are an underlying cause of 3.1 million child deaths annually and are a contributing factor in 45% of child deaths⁽¹⁾. An estimated 28% of children in low- and middle-income countries are chronically malnourished and globally 165 million children under the age of 5 years are stunted⁽¹⁾. Early childhood undernutrition is associated with cognitive and physical defects, increased susceptibility to infections and higher risk of death^(2,3). Given the long-lasting sequelae of child undernutrition, effective, early interventions are critical for maximizing developmental

potential and facilitating post-conflict recovery by improving the health status of future generations.

Conflict in the Democratic Republic of Congo (DRC) resulted in an estimated 5 million deaths between 1994 and 2003, primarily from undernutrition and disease⁽⁴⁾. DRC's eastern provinces of North and South Kivu were among the most severely affected by the conflict and child health and nutritional status has remained poor. South Kivu has the highest rate of under-five mortality (139 deaths/1000 live births) and stunting prevalence (53%) of all provinces in DRC, where, nationally, the under-five mortality rate is 104 deaths/1000 live births and stunting prevalence is 43%⁽⁵⁾. To address food insecurity and child undernutrition in South Kivu Province, the Office of Food for Peace of the US Agency for International Development funded a development food assistance programme, Jenga

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Jamaa II, from 2012 to 2016. Jenga Jamaa II interventions aimed to improve food security and child nutrition through different pathways and included: (i) the prevention of malnutrition in children under two approach (PM2A)⁽⁶⁾; (ii) farmer field schools (FFS); (iii) farmer-to-farmer training (F2F); and (iv) women's empowerment groups (WEG).

Evidence on the effectiveness of these types of intervention in improving child diet and nutrition outcomes is mixed. PM2A interventions, which include rations distributed to pregnant and lactating women and children aged 6–23 months, along with a health and nutrition behaviour change strategy, were found to improve child diet in Burundi and were associated with a 4–6% reduction in stunting prevalence in Haiti^(6,7); however, the approach, which is commonly used in development food assistance programmes, has not been widely evaluated with respect to child diet and growth outcomes. Most of the agricultural interventions that have been evaluated in relation to child diet and nutritional status have consisted of household gardens or promotion of one specific crop, and less is known about the effects of larger-scale interventions designed to increase harvest yields through education and improved seeds and tools^(8–10). Numerous studies have identified aspects of women's empowerment, particularly autonomy, to be positively associated with child diet and nutritional status, but there have been few evaluations of multifaceted women's empowerment approaches in relation to improvements in child diet and growth indicators^(11–15). Income-generating interventions targeted at women have been successful in improving child outcomes in food-insecure contexts including Ghana and Ethiopia^(16,17). The present study evaluated the effectiveness of the four different Jenga Jamaa II interventions with respect to child diet and nutrition indicators and aimed to contribute to the evidence base for nutrition programming in post-conflict settings; study results on household food security are presented elsewhere⁽¹⁸⁾.

Methods

Setting and interventions

Jenga Jamaa II was implemented by the Adventist Development and Relief Agency in Fizi and Uvira territories of South Kivu between 2011 and 2016 (Fig. 1). The programme aimed to address high levels of household food insecurity and child undernutrition and reached over 258 000 beneficiaries. The objectives of Jenga Jamaa II were to: (i) increase incomes among food-insecure farming households (FFS and F2F interventions); (ii) improve the health and nutritional status of children under 5 years of age (PM2A); and (iii) empower women (via WEG) in food-insecure communities (Table 1).

The FFS intervention provided hands-on education on farming practices, post-harvest natural resource management, and business skills to farmers through biweekly

trainings; participants also received starter packages of seeds and tools. After the two-year FFS intervention, many beneficiaries transitioned to farmer business associations, which were designed to improve access to credit and marketing opportunities. In F2F, which was designed as a less resource-intensive and scalable approach to improving agricultural production, FFS participants trained three farmers from their community on FFS techniques. PM2A targeted pregnant women and children under 2 years of age using the care group method, where volunteer leader mothers were trained in child health and nutrition and messages were disseminated to beneficiaries in care group meetings and during home visits; homestead gardens were also promoted and monthly rations (corn–soya blend and vitamin A-fortified oil) were provided. WEG met weekly and served as a delivery mechanism for a variety of interventions including literacy and numeracy, business and marketing training, and income-generating activities (primarily soap-making, bread-making and fish-drying). WEG beneficiaries were provided with a starter kit of basic materials for their income-generating activity and savings and credit groups were started in each WEG; many WEG participants also received goats and energy-efficient stoves.

Sample size

The study was powered to detect a $\geq 10\%$ reduction in prevalence from baseline of household food insecurity indicators (the primary outcome measure) within each comparison group, which yielded a minimum sample size of 325 households per group or 1625 households in total. This sample size was sufficient to detect endline differences from the control group of $\geq 8.5\%$ for the proportion of children with adequate dietary diversity and $\geq 10.5\%$ for stunting prevalence, with a significance level of 0.05.

Study design and data collection

A quasi-experimental matched design was used, where communities planned to receive one intervention (as opposed to communities that received multiple interventions) were eligible for participation so that the effect of individual interventions could be assessed. Communities were matched by territory (Fizi or Uvira) and livelihoods zone (mountains, plains or lakeside) into thirteen sets of similar villages. In the PM2A villages, two PM2A groups, each with approximately fifteen beneficiaries, each were selected for participation. In WEG villages, one WEG group of twenty-five participants was selected; each WEG beneficiary was matched with a female neighbour not participating in Jenga Jamaa II interventions, who was enrolled as a member of the control group. In agriculture villages, one FFS with approximately thirty participants was enrolled; one of three F2F trainees of each FFS participant was randomly selected to comprise the F2F group. Enrolment occurred between August and October 2012,



Fig. 1 (colour online) Map of the Jenga Jamaa II programme and study area⁽³⁸⁾

Table 1 Summary of Jenga Jamaa II objectives and interventions

Objective	Increase incomes among food-insecure farming households	Improve the health and nutritional status of children	Empower women in food-insecure communities
Intervention components	<p>FFS</p> <ul style="list-style-type: none"> • Biweekly training on agricultural methods by project staff • Provision of seeds and tools 	<p>F2F</p> <ul style="list-style-type: none"> • Training by FFS beneficiaries of other farmers in their communities <p>PM2A</p> <ul style="list-style-type: none"> • Monthly care groups with behavior change education • Monthly rations • Homestead gardens • Health systems support 	<p>WEG</p> <ul style="list-style-type: none"> • Weekly meetings with literacy, numeracy and business training • Starter kits for income generation • Goats • Energy-efficient stoves • Saving/lending groups

FFS, farmer field schools; F2F, farmer-to-farmer training; PM2A, prevention of malnutrition in children under two approach; WEG; women's empowerment groups.

and a total of 1820 beneficiaries and 1385 child household members born between July 2010 and December 2012 were enrolled.* Participants were followed for 3-5 years

*This age group was identified because children in the PM2A group (aged 6-24 months on 1 July 2012; born between July 2010 and December

through February/March 2016, regardless of if they graduated or dropped out of the intervention. Data were

2011), lactating mothers (children aged 0-6 months; born between January 2011 and June 2012) and pregnant women (infants due between July 2012 and December 2012, where pregnant mothers were generally enrolled at/after 4 months' gestation) were eligible for rations.

collected in eight semi-annual surveys (August/September and February/March) to account for seasonality.

Adequacy of children's diet was assessed using the WHO indicators for infant and young child feeding practices⁽¹⁹⁾. Caregiver reports of child food consumption on the preceding day were used to determine the number of food groups consumed which equated to the dietary diversity score (range 0–7); children consuming ≥ 4 food groups were classified as achieving minimum dietary diversity. To ascertain meal frequency, mothers were asked the number of meals and snacks consumed by their child the previous day. Children were classified as achieving minimum meal frequency if meal frequency was ≥ 2 for breast-fed infants aged 6–8 months, ≥ 3 for breast-fed children aged 9–23 months and ≥ 4 times for non-breast-fed children older than 6 months. Children who achieved both minimum meal frequency and dietary diversity were classified as achieving minimum acceptable diet. The questionnaire was developed in English and translated to Swahili, the predominant local language, and was finalized following pilot testing and translation review. Child anthropometric data (weight and height) were collected at each survey. Weight was measured using Tanita Mommy and Baby Infant Scales, model 1582 (Arlington Heights, IL, USA) and height using Shorr Productions height boards (Olney, MD, USA); recumbent length was measured for children 6–23 months of age and height for children aged ≥ 24 months.

Enumerators were recruited from programme staff and data collection was supervised by a field coordinator; in most cases, interviews were completed by staff members who did not have regular interaction with the respondent. Enumerators received an orientation to the study and training on ethical conduct, questionnaire administration and anthropometric assessment at the beginning of the study and standardization for anthropometric measurements was conducted; refresher trainings were conducted prior to each survey. Due to high levels of illiteracy, oral consent was obtained at enrolment and each subsequent survey; participants were reminded that participation was voluntary and that declining would not impact benefits received from Jenga Jamaa II. Participants received a small incentive, worth approximately \$US 1, for participation in each survey, most often soap.

Statistical analysis

Data analysis was performed using the statistical software package Stata version 13. Exploratory analysis included calculating unadjusted means and prevalence of binary indicators for each survey and identifying outliers; assessing patterns of missing data and dropouts across study groups and differences in outcomes between those who had dropped out or been absent for the previous survey and those who had not; and assessing correlation over time using autocorrelation matrices for continuous

outcomes and looregrams for binary outcomes⁽²⁰⁾. Children who died (n 73) were excluded from the analysis* and missing values for maternal age (n 35) and education (n 45) were assigned the mean and mode of those variables, respectively, so they could be included in the analysis.

Continuous Z-scores for height-for-age (HAZ) and weight-for-age (WAZ) were assessed. The primary outcome indicators for child growth were stunting (HAZ < -2) and underweight (WAZ < -2); wasting was not included as a key indicator in the final analysis due to low prevalence (typically from 1 to 3% at each survey). Anthropometric Z-scores for children 6–59 months of age were calculated using the 2006 WHO child growth standards with the user-written Stata program Zscore06⁽²¹⁾. To estimate differences in outcomes between groups over time, the ANCOVA approach was used to estimate mean change in the outcome variable by comparing the last follow-up with baseline separately for each treatment group; the outcome at endline for each intervention group was then compared with the control group. ANCOVA allows precision of the estimate to be gained by accounting for chance imbalance across intervention groups in baseline variables that are prognostic for the outcome of interest (e.g. stratification variables and the baseline outcome). A linear model for the outcome at the last follow-up was used with main terms for intervention group (four dummy variables), the baseline outcome, two stratification variables (territory and livelihoods zone) and maternal age and education. Propensity scores were created for each intervention group to account for the non-randomized design and models included propensity score weights; variables considered prognostic of treatment group assignment and used to define the propensity score weights included participant sex, age and education,† household landownership and number of income sources, and number of children < 2 years in the household. Model coefficients for each treatment group represent the estimated difference compared with the control group for that respective intervention group.

To account for possible clustering within a household, the model included a random intercept defined for each household (i.e. allowing the children within a household to be correlated, children from different households are assumed independent). Due to lower child participation rates towards the end of the study, a multiple imputation approach was used to create complete data sets; missing values were replaced by values sampled from a distribution defined by the fit of a linear regression model for the outcome at a given follow-up as a function of previous outcomes, child age and sex. The methods described above were applied to each survey data set and then

*Child deaths were distributed relatively evenly across the intervention groups, with 17–25% of deaths in each group.

†Maternal age and education were used for the control group in lieu of beneficiary characteristics.

averaged using Rubin’s method to obtain final estimates⁽²²⁾.

For binary outcomes, prevalence at the last follow-up was estimated for each intervention group; the treatment effect was defined as the difference in prevalence comparing each intervention group with the control. The analysis included adjustment for the stratification variables, baseline outcome and maternal characteristics. To estimate the treatment effects, an outcome regression estimator referred to as the doubly robust weighted least-squares estimator was used, which is synonymous to the ANCOVA approach but applies to non-continuous outcomes^(23,24). Standards errors, confidence intervals and *P* values were generated using a bootstrap. For binary outcomes related to children’s diet where only a small percentage of children achieved minimum meal frequency and acceptable diet, Fisher’s exact test was used.

Ethical approvals

Approval to conduct operations research was obtained from local authorities in the relevant administrative areas and by the Johns Hopkins Bloomberg School of Public Health Institutional Review Board.

Results

A total of 1820 households were enrolled in the study of which 1113 (61.2%) had one or more children enrolled. Characteristics at enrolment of children and households

with children are presented in Table 2. A total of 1385 children were enrolled (Fig. 2) and 1312 children were included in the analysis, where children who died during the follow-up period (*n* 73) were excluded. The mean age of children at enrolment was 11.4 months; children in the PM2A group were younger at enrolment (mean age 10.6 months) compared with other groups. Of participating children, 48.1% were male; this proportion was similar across groups. Mean household size was 6.5 members and differed significantly between groups, ranging from 6.1 in the F2F group to 6.8 in the FFS group. Mean maternal age was 29.2 years and differed significantly between groups, ranging from 28.0 years (PM2A) to 31.9 years (WEG); mothers had on average 3.0 years of education and this was similar across groups. Slightly more than one-fifth (22.6%) of households had a pregnant member at baseline; this proportion differed significantly between groups and was notably higher in the PM2A group (29.1%). Households had an average of 1.0 children aged <2 years and 2.1 children aged 2–4 years; the mean number of children <2 years old differed significantly between groups. A majority (68.9%) of households reported farmland ownership and this proportion was similar across groups. A mean of 1.2 income sources were reported; this differed significantly between groups and was highest in the FFS group (1.3) and lowest in the control group (1.0). With respect to location, more than half (52.0%) of participants resided in Uvira territory and the remaining 48.0% in Fizi territory. The majority lived in the plains livelihoods zone (54.4%) with minorities in the lakeside (31.1%) and

Table 2 Characteristics at enrolment of Jenga Jamaa II study children and households, South Kivu, Eastern Democratic Republic of the Congo

	Total		WEG		PM2A		FFS		F2F		Control		<i>P</i> value*
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Children	<i>n</i> 1312†		<i>n</i> 234		<i>n</i> 393		<i>n</i> 206		<i>n</i> 215		<i>n</i> 265		
Age (months)	11.4	7.2	12.5	7.3	10.6	6.9	13.0	8.1	11.7	6.7	10.3	6.7	<0.001
Sex (male, %)	48.1		44.9		49.6		48.5		45.6		50.6		0.636
Households	<i>n</i> 1243		<i>n</i> 207		<i>n</i> 363		<i>n</i> 214		<i>n</i> 207		<i>n</i> 246		
Household size	6.5	2.3	6.9	2.3	6.3	2.3	6.8	2.4	6.1	2.3	6.5	2.4	0.001
Maternal age (years)	29.2	7.2	31.9	7.9	28.0	5.7	30.1	8.1	28.6	7.0	28.3	7.7	<0.001
Maternal education (years)	3.0	3.2	3.1	3.3	2.9	3.4	2.6	2.9	2.9	3.2	3.3	3.4	0.162
No. of children aged <2 years	1.0	0.4	1.0	0.4	1.0	0.4	0.9	0.4	0.9	0.3	1.0	0.4	0.005
No. of children aged 2–4 years	2.1	0.9	2.1	0.8	2.1	0.9	2.1	0.9	1.9	0.8	2.1	0.9	0.090
Pregnant member (%)	22.6		21.6		29.1		23.5		15.1		19.6		0.002
No. of income sources	1.2	0.9	1.2	1.0	1.2	0.9	1.3	0.9	1.2	1.0	1.0	0.9	0.045
Land ownership (%)	68.9		69.5		72.1		69.7		63.0		68.5		0.291
Territory (%)													
Fizi	48.0		51.2		47.4		45.3		50.2		46.8		0.718
Uvira	52.0		48.8		62.6		54.7		48.8		53.2		
Livelihoods zone (%)													
Plains	54.4		49.3		53.4		63.1		53.6		53.3		0.298
Lakeside	31.1		35.7		31.4		24.3		31.9		31.7		
Mountains	14.6		15.0		15.2		12.6		14.5		15.0		

WEG, women’s empowerment groups; PM2A, prevention of malnutrition in children under two approach; FFS, farmer field schools; F2F, farmer-to-farmer training.

*Five group comparison using Pearson’s χ^2 for proportions and *F* test for means (ANOVA); significant *P* values are indicated in bold font.

†Excludes seventy-three children who died in the follow-up period.

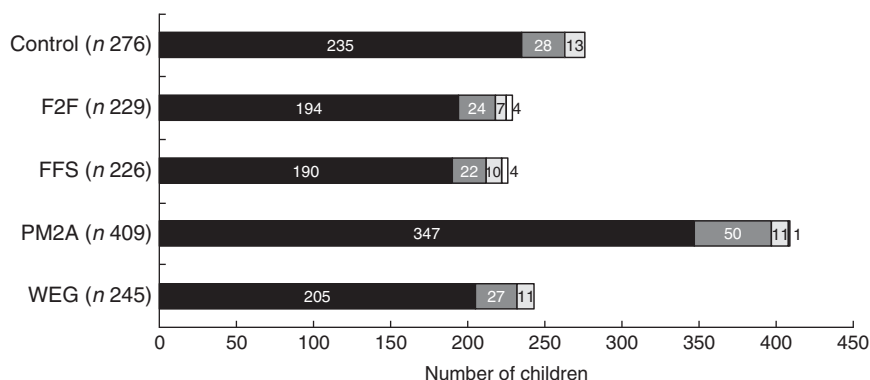


Fig. 2 Number of children enrolled in the Jenga Jamaa II programme over time (■, August/September 2012; ■, February/March 2013; □, August/September 2014; □, February/March 2014), by study group (F2F, farmer-to-farmer training; FFS, farmer field schools; PM2A, prevention of malnutrition in children under two approach; WEG; women's empowerment groups), from South Kivu, Eastern Democratic Republic of the Congo. In total, 1385 children were enrolled

mountain (14.6%) zones. There were no significant differences in residence location by territory or livelihoods zone between groups.

Children's diet outcomes

Adjusted analysis of the endline differences in children's dietary diversity, meal frequency and minimum acceptable diet compared each intervention group with the control group and are presented in Table 3. Both the PM2A group ($\beta=0.55$; 95% CI 0.20, 0.91; $P=0.002$) and the FFS group ($\beta=0.46$; 95% CI -0.01 , 0.93; $P=0.049$) had significantly higher mean dietary diversity scores compared with the control group at endline, whereas the WEG and F2F groups had dietary diversity scores similar to the control group. The prevalence of children achieving minimum dietary diversity, defined as consuming ≥ 4 food groups on the preceding day, ranged from 28.0 to 39.7%; children in both the PM2A and FFS groups had significantly higher prevalence of achieving target dietary diversity as compared with controls (PM2A: 16.9%; 95% CI 4.0, 29.7%; $P=0.009$; FFS: 14.4%; 95% CI 0.2, 28.5%; $P=0.042$). The three principal intervention groups (WEG, FFS and PM2A) all had significantly higher mean meal frequency compared with the control group (WEG: 0.25; 95% CI 0.02, 0.47; $P=0.027$; FFS: 0.30; CI 0.05, 0.55; $P=0.015$; PM2A: 0.32; 95% CI 0.15, 0.49; $P<0.001$). Very few children attained minimum meal frequency, ranging from a low of 0.7% (control group) to a high of 7.6% (PM2A group). Except for the PM2A group, which had a significantly higher proportion of children achieve minimum meal frequency ($P=0.001$), there were no significant differences in meal frequency between the other intervention groups and the control group. The final dietary indicator assessed was minimum acceptable diet, a composite indicator that reflects children who have attained both minimum dietary diversity and minimum meal frequency. At endline, the proportion of children achieving minimal

acceptable diet ranged from a low of 0.7% (control group) to 5.8% (PM2A); the PM2A group was the only group with a statistically significantly higher percentage of children achieving minimum acceptable diet as compared with controls ($P=0.009$).

Child growth outcomes

Adjusted analysis of the endline differences in child stunting and underweight compared each intervention group with the control group and are presented in Table 4. No significant differences in endline HAZ were found between any of the intervention groups compared with the control group. Similarly, there were no significant differences observed in endline stunting prevalence between any of the intervention groups and the control group; endline stunting prevalence was lowest among the PM2A group (54.7%; 95% CI 48.9, 60.6%) and highest among the F2F group (69.1%; 95% CI 60.2, 78.0%); however, there were no statistically significant differences in endline stunting prevalence between any comparison group and the control group, indicating that programme interventions did not improve linear growth. Similar findings were observed for child underweight measures, where no significant differences between intervention groups and the control group were observed for adjusted endline measures of WAZ and underweight prevalence; endline underweight prevalence was lowest in the FFS (22.3%) and PM2A groups (23.0%) and highest in the F2F group (34.4%). Despite the lack of statistically significant differences in endline stunting and underweight prevalence, the adjusted difference in prevalence of stunting and underweight between the PM2A group and controls was -4.0 and -6.8% , which is a considerable difference in a programmatic context. Similarly, the adjusted difference in prevalence of underweight between the FFS group and the control group was -7.6% , indicating that both PM2A and FFS interventions may have the potential to impact

Table 3 Differences in child diet measures at endline, Jenga Jamaa II programme, South Kivu, Eastern Democratic Republic of the Congo, February/March 2016

	Adjusted mean difference in child dietary diversity score compared with control group* (n 1306)			Adjusted prevalence of children achieving target dietary diversity† (n 780)			Adjusted difference in prevalence of children achieving target dietary diversity compared with control group‡ (n 780)		
	Estimate	95 % CI	P value	Estimate	95 % CI	P value	Estimate	95 % CI	P value
Dietary diversity									
WEG	0.27	-0.19, 0.72	0.240	28.0	19.8, 36.3	<0.001	5.2	-7.2, 17.5	0.403
PM2A	0.55	0.20, 0.91	0.002	39.7	31.8, 47.7	<0.001	16.9	4.0, 29.7	0.009
FFS	0.46	-0.01, 0.93	0.049	37.2	25.7, 48.7	<0.001	14.4	0.2, 28.5	0.042
F2F	0.19	-0.37, 0.74	0.499	32.8	22.4, 43.2	<0.001	9.9	-3.0, 22.9	0.126
Control	-	-	-	22.9	14.3, 31.4	-	-	-	-
Meal frequency and minimum acceptable diet									
	Adjusted mean difference in meal frequency compared with control group‡ (n 1271)			Adjusted prevalence of children achieving minimum meal frequency‡ (n 792)			Adjusted prevalence of children achieving minimum acceptable diet (n 792)		
	Estimate	95 % CI	P value	Estimate	95 % CI	P value	Estimate	95 % CI	P value
WEG	0.25	0.02, 0.47	0.027	2.7	0.7, 6.8	0.371	2.0	0.4, 5.8	0.622
PM2A	0.32	0.15, 0.49	< 0.001	7.6	4.7, 11.3	0.001	5.8	3.3, 9.2	0.009
FFS	0.30	0.05, 0.55	0.015	1.6	0.2, 5.8	0.595	0.8	0.0, 4.4	1.000
F2F	0.08	-0.17, 0.32	0.532	1.0	0.0, 5.6	1.000	1.0	0.0, 5.6	1.000
Control	-	-	-	0.7	0.0, 3.8	-	-	-	-

WEG, women's empowerment groups; PM2A, prevention of malnutrition in children under two approach; FFS, farmer field schools; F2F, farmer-to-farmer training.

P values test for significant difference compared with the control group using Fisher's exact test; significant P values are indicated in bold font.

*Adjusted for baseline dietary diversity score, territory, livelihoods zone, maternal age and maternal education.

†Adjusted for baseline minimum dietary diversity, territory, livelihoods zone, maternal age and maternal education.

‡Adjusted for baseline meal frequency, territory, livelihoods zone, maternal age and maternal education.

Table 4 Differences in child nutrition measures at endline, Jenga Jamaa II programme, South Kivu, Eastern Democratic Republic of the Congo, February/March 2016

	Adjusted mean difference in HAZ compared with control group*			Adjusted prevalence of child stunting†			Adjusted difference in prevalence of child stunting compared with control group†		
	Estimate	95% CI	P value	Estimate	95% CI	P value	Estimate	95% CI	P value
Child stunting (n 1288)									
WEG	0.10	-0.25, 0.45	0.572	62.3	54.4, 70.3	<0.001	3.5	-8.3, -15.3	0.549
PM2A	0.16	-0.13, 0.45	0.280	54.7	48.9, 60.6	<0.001	-4.0	-14.1, 6.0	0.422
FFS	-0.01	-0.35, 0.34	0.958	60.2	50.8, 69.6	<0.001	1.4	-10.7, 13.6	0.812
F2F	-0.27	-0.65, 0.10	0.148	69.1	60.2, 78.0	<0.001	10.3	-2.2, 22.9	0.100
Control	-	-	-	58.8	50.1, 67.5	<0.001	-	-	-
	Adjusted mean difference in WAZ compared with control group‡			Adjusted prevalence of child underweight§			Adjusted difference in prevalence of child underweight compared with control group§		
	Estimate	95% CI	P value	Estimate	95% CI	P value	Estimate	95% CI	P value
Child underweight (n 1291)									
WEG	0.00	-0.26, 0.25	0.986	29.1	21.2, 37.1	<0.001	-0.7	-11.7, 10.3	0.898
PM2A	0.11	-0.09, 0.31	0.269	23.0	17.6, 28.4	<0.001	-6.8	-16.3, 2.7	0.151
FFS	0.12	-0.13, 0.37	0.350	22.3	14.8, 29.8	<0.001	-7.6	-17.7, 2.5	0.134
F2F	-0.20	-0.48, 0.08	0.153	34.4	24.9, 43.9	<0.001	4.6	-8.2, 17.4	0.474
Control	-	-	-	29.8	22.0, 37.7	<0.001	-	-	-

HAZ, height-for-age Z-score; WAZ, weight-for-age Z-score; WEG, women's empowerment groups; PM2A, prevention of malnutrition in children under two approach; FFS, farmer field schools; F2F, farmer-to-farmer training. P values test for significant difference compared with the control group using Fisher's exact test; significant P values are indicated in bold font.

*Adjusted for baseline HAZ, territory, livelihoods zone, maternal age and maternal education.

†Adjusted for baseline stunting status, territory, livelihoods zone, maternal age and maternal education.

‡Adjusted for baseline WAZ, territory, livelihoods zone, maternal age and maternal education.

§Adjusted for baseline underweight status, territory, livelihoods zone, maternal age and maternal education.

child growth outcomes, even though the study was not adequately powered to detect these levels of differences with statistical significance.

Discussion

From a programmatic perspective, the PM2A and FFS interventions were modestly successful in increasing dietary diversity, with children in these groups consuming approximately 0.5 additional food groups daily and 15% more children meeting dietary diversity targets as compared with the control group. At endline, the PM2A group had the highest prevalence of children achieving minimum meal frequency and minimum acceptable diet as compared with the control group; however, given that <6% of children in the PM2A group achieved minimum acceptable diet, the intervention cannot be considered as effective in improving child diet. In terms of child nutrition outcomes, no statistically significant differences were found between intervention groups and the control group at endline for mean Z-scores or prevalence rates for either stunting or underweight. However, compared with the control group, stunting prevalence was 4% lower among the PM2A group and underweight prevalence was approximately 7% lower in both the PM2A and FFS groups, which are notable differences that suggest these interventions do impact child nutritional status and that further research powered to assess child anthropometric indicators is warranted.

With respect to the women's empowerment intervention, different aspects of empowerment including economic, education and autonomy measures have been positively associated with child feeding indicators in various developing country settings^(11–15,25–27). The present study did not measure the impact of the WEG intervention on women's autonomy or income; however, the poor status of women in the DRC may have made it especially challenging to improve women's status and subsequently to improve child outcomes. Labour-saving techniques and non-agricultural income-generating activities supported by WEG had the potential to provide women with more time and resources to feed children throughout the day, but improvements in child feeding practices were not observed. This indicates the possibility that gains realized by WEG may have been too small to be meaningful in terms of improving household diet and women's time allocation, or that education on child feeding practices should accompany WEG activities if improving child nutrition is an objective.

With respect to agricultural interventions, children in the FFS group had improved dietary diversity and meal frequency compared with the control group. The FFS intervention was more intensive than F2F, with beneficiaries receiving tools, seeds and regular training on agricultural techniques, whereas F2F relied on FFS participants to disseminate information and therefore may have had less

effect. The potential pathways linking FFS with improvements in child diet include increased household income, access to more diverse foods and caregivers spending less time in food production. Overall, there are a multitude of types of agricultural intervention and the differences in the intervention approaches make it difficult to compare to the FFS and F2F results reported here. FFS interventions have mainly been evaluated with respect to the adoption of improved farming practices, household incomes and agricultural production⁽²⁸⁾. Agricultural interventions that address multiple types of human capital, for example nutrition education and gender issues, along with the agricultural intervention have been found to be most effective in improving nutrition measures; however, interventions were not always sufficient to effect change and negative or mixed results were not uncommon^(29,30). A review of agricultural and animal husbandry interventions suggests that very little evidence is available on dietary changes in poor households and that no evidence exists for improvement in child anthropometric measures; however, the authors also noted the current state of evidence was too limited to adequately assess if agricultural interventions are effective in improving child nutrition⁽¹⁷⁾. Findings from the present study, where children in the FFS group had similar stunting prevalence and underweight prevalence, indicate the potential for FFS to impact child nutrition, and along with the review by Massett *et al.* suggest the need for additional research.

The PM2A was developed after a study in Haiti showed that a preventive approach was superior to a therapeutic approach with respect to child anthropometric outcomes⁽⁶⁾. PM2A has not been rigorously evaluated in a multitude of settings; however, it has been shown to positively impact child dietary diversity in Burundi⁽⁷⁾. Food supplementation of infants in African settings has been shown to improve growth in several cases^(31,32); yet, positive findings are not consistently reported and are from a range of products which may not be comparable to the ration provided as part of the Jenga Jamaa II PM2A intervention. A study conducted in South Kivu found that supplementation with ready-to-use-complementary foods was not effective in reducing prevalence of stunting or underweight, suggesting that supplementation alone may be insufficient in the context of Eastern DRC⁽³³⁾. Care groups, a core element of PM2A programme delivery, have been shown to reduce the prevalence of child underweight and to improve child health outcomes more broadly^(34,35). While findings reported from care group interventions are increasingly positive, the evidence is largely centred on the efficacy of specific interventions rather than a package of interventions delivered in a field setting⁽³⁶⁾. The effects of the Jenga Jamaa II PM2A intervention, where children's dietary diversity and minimum acceptable diet were significantly improved and there were modest (but not statistically significant gains) in anthropometric measures,

demonstrate that such an intervention package can be effective in a food-insecure post-conflict context. While statistically significant findings were observed for child diet measures, gains were modest from a programmatic perspective and suggest that either intervention selection or delivery needs to be modified if more widespread population-level gains are to be achieved. The challenges in producing gains in diet and nutrition outcomes are likely due to barriers to optimal feeding practices including poverty, high prevalence of food insecurity and high work burden, which remained in many households despite the different Jenga Jamaa II programme interventions. In addition, poor access to safe drinking-water and to improved sanitation and health services is prevalent in South Kivu, both of which are known contributors to poor child nutritional status.

Limitations

Several methodological issues must be considered when assessing study findings. Children's diet indicators are designed to evaluate the diets of children 6–23 months of age; the same indicators were used throughout the study period so that change over time could be assessed; the target of ≥ 4 meals per day was maintained for children 25–59 months of age. Target meal frequency increases for non-breast-fed children (minimum 4 times, compared with 2–3 times for breast-fed children) so it became more difficult for children to achieve this target as they grew older; another concern is that mothers' reports of dietary diversity and meal frequency may have been less accurate for older children who are often left in the care of others. With respect to anthropometry, it was difficult to obtain reliable birth dates. After the fifth survey discrepancies were resolved by utilizing the mid-point if dates varied by a few months; or if dates varied by years, by using the child's HAZ to determine the likely year of birth. Lack of precision in estimating birth dates may have affected results of the analyses for WAZ, HAZ, stunting and underweight. As children grew older, fewer were present during the surveys, often due to illness or being sent away to live with relatives. With the multiple imputation approach, we assumed that children missing anthropometric ($n = 664$) and dietary ($n = 605$) outcomes at endline were otherwise similar to children whose outcomes were observed at the last time point. Finally, the study was not sufficiently powered to detect changes in child nutrition outcomes, which were secondary outcome measures, limiting the strength of conclusions.

Conclusions

PM2A and FFS interventions resulted in statistically significant gains in child dietary diversity and some reduction in stunting and underweight that were programmatically but not statistically significant. A minority of children

achieved target dietary diversity following the interventions; this proportion was highest among PM2A which was the only intervention that included a behaviour change component around children's diet and feeding practices. These findings align with the conclusions of recent reviews which suggest that integration of social behaviour change communication and education may be an important factor in achieving change in nutrition outcomes in the context of development programmes that aim to increase agricultural production and household income⁽²⁸⁾. When considering the context of Eastern DRC, where chronic food insecurity and poverty are widespread, even small gains in child diet measures can be considered laudable, particularly when they are sustained following the intervention as was the case with Jenga Jamaa II. While community-based prevention programmes are recognized as an important approach to improving child health and nutrition in resource-poor settings with weak health systems and high levels of child mortality, the evidence base remains limited with respect to their effectiveness⁽³⁶⁾. With both maternal and child nutrition and household agricultural interventions, improvements in dietary diversity measures have not been shown to translate into gains in nutritional status at scale^(36,37). Recommendations for future Food for Peace development programming in similar resource-poor contexts include ensuring a strong social behaviour change and communication element for all interventions that aim to improve infant and young child feeding practices, particularly to increase meal frequency. Expanding the focus on reducing women's work burden and access to labour-saving technology could allow women to spend more time caring for young children. Interventions that are more intensive, engage both male and female household members, and integrate activities that improve household agricultural production and income along with knowledge transfer for health and nutrition education may be more impactful, particularly in resource-poor and highly food-insecure settings.

Several critical questions remain, and further research is needed to determine whether these results are specific to the context of Eastern DRC or are also applicable to similar settings in sub-Saharan Africa or other low- and middle-income countries. With greater global focus on multi-sectoral nutrition interventions, understanding which interventions or intervention packages are most effective will remain an important question. Rigorous evaluation studies across a range of settings are required to gain a complete understanding of how context, interventions and programme delivery translate to gains in children's diet and nutritional status.

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