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The impact of an integrated value chain intervention on household poultry production in Burkina Faso: evidence from a randomized controlled trial

Jessica Leight[a], Josué Awonon[a], Abdoulaye Pedehombga[b], Rasmané Ganaba[a], Elena Martinez[a], Jessica Heckert[a] and Aulo Gelli[a]

[a]Poverty, Health and Nutrition Division, International Food Policy Research Institute (IFPRI), Washington, United States; [b]AFRICSanté, Bobo Dialousso, Burkina Faso

ABSTRACT

This article reports on a cluster-randomised controlled trial conducted in rural Burkina Faso evaluating a multifaceted intervention, SELEVER, that seeks to increase poultry production by delivering training and strengthening of village-level institutions providing veterinary and credit services. Households exposed to the intervention significantly increase their use of poultry inputs (veterinary services, enhanced feeds, and deworming), and report more poultry sold and higher revenue. However, there is no evidence of an increase in profits. This evidence is consistent with the hypothesis that the return to inputs may not be sufficient to counterbalance the market costs of these inputs.

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1 Introduction

Recent debates in development in both research and policy have increasingly focused on the potential of livestock and poultry production as a sustainable strategy to reduce poverty for poor rural households (Rawlins et al. 2014; Miller et al. 2014; Jodlowski et al. 2016; Phadera et al. 2019; Blattman 2017). Major stakeholders have argued that poultry are an attractive investment, requiring minimum inputs and generating a consistent stream of revenue (Gates 2016). Data from the Demographic and Health Surveys suggest that in eastern and southern Africa as well as the Sahel, more than half of all households engage in poultry production (Headey and Hirvonen 2015). In Burkina Faso, the site of this evaluation, 80% of households own poultry (Gelli et al. 2020). In addition, the prices for poultry meat as well as eggs are relatively high, suggestive of supply constraints and potentially high returns to households who can successfully commercialise poultry (Headey and Alderman 2019).

This article reports on a cluster-randomised controlled trial conducted in rural Burkina Faso evaluating a multifaceted intervention SELEVER (Soutenir l'Exploitation Familiale pour Lancer l'Élevage des Volailles et Valoriser l'Économie Rurale) that seeks to increase poultry production and improve the nutritional status of women and children (Gelli et al. 2017). SELEVER is delivered by a non-governmental organisation, Tanager, and includes three key program elements focused on increasing households' engagement in poultry: training for producer households, training and

CONTACT Jessica Leight j.leight@cgiar.org International Food Policy Research Institute (IFPRI), 1201 Eye St, Washington, Washington 20006-1002, United States

enhanced provision of equipment to village-level providers of vaccination services, and enhanced access to credit.[1] Importantly, unlike other major livestock-related programmes, SELEVER does not include any transfer of assets or any provision of subsidised or free inputs.

Our objective in this analysis is to evaluate the effects of the intervention on household poultry production using an endline survey conducted in the lean season following approximately two years of intervention implementation. The sample includes 90 villages in 45 communes across three regions (Boucle du Mouhoun, Centre-Ouest, and Hauts-Bassins).[2] Households with women of reproductive age and a young child (aged two to four at baseline) were eligible for inclusion in the sample and were randomly selected, yielding a target subsample of 1080 households at baseline. The realised longitudinal sample constituted 1054 households,[3] and 1019 of these households were surveyed in this follow-up survey, for an attrition rate of only 3.3%.

The primary analysis is an intention-to-treat specification, and pre-specified primary outcomes include poultry production, sales and profits. Pre-specified secondary outcomes include poultry-related knowledge, use of poultry inputs, credit access and utilisation, marketing practices, and poultry mortality (Gelli et al. 2017). There is no evidence of any effect of the intervention on the probability that households raise or sell poultry, or reported flock size or flock value. However, households in communes exposed to SELEVER report significantly higher revenue from poultry sales in the lean season, an increase of 34% relative to average revenue in control households of $50 over a six month recall period. They also report significantly higher input costs, an increase of around 40% relative to the average input cost of $13 in the control arm using the same recall period. The effect on profits is positive, but moderate in magnitude and not statistically significant, consistent with the hypothesis that the increase in revenue has been sufficient only to compensate for households' higher incurred costs.

These patterns can also be unpacked in more detailed analysis of secondary outcomes. It is clear that households have meaningfully shifted their poultry production practices, and are significantly more likely to use inputs including vaccination services, concentrate feeding, and deworming. Relative to households in the control arm, use of concentrate feeds roughly doubles, and the prevalence of deworming increases by about a third. This increased input use is not matched by any increased use of credit. On the revenue side, households report selling more poultry and there is some evidence of more consumption of own-produced poultry. However, there is no significant shift in price or marketing choices.

This article contributes to a growing literature analysing the effect of interventions targeting livestock production among poor households. In economics, existing interventions have primarily focused on livestock transfers, an important component of the graduation models evaluated in Bangladesh by Bandiera et al. (2017) and in a six-country study by Banerjee et al. (2015). A similar programme implemented in Zambia is analysed in Phadera et al. (2019) and Kafle, Michelson, and Winter-Nelson (2019). While households in graduation programmes can choose the asset that will be transferred, livestock is a common choice. These programmes have had positive effects on multiple measures of household economic welfare, including asset cumulation, poverty, and resilience. In addition, a number of other papers have evaluated more targeted livestock transfers outside of the context of multidimensional programming (Darrouzet-Nardi et al. 2016; Kafle, Winter-Nelson, and Goldsmith 2016; Jodlowski et al. 2016; Miller et al. 2014; Rawlins et al. 2014; Thompson and Magnan 2017).

There is very limited evidence around interventions that provide training around livestock production without an asset transfer. One recent paper analysed a programme providing cows to households in Rwanda and found it was differentially effective when training was also provided, though the offer of training was not randomised (Argent, Augsburg, and Rasul 2014). Janzen et al. (2018) analyse a randomised controlled trial in Nepal in which three arms received different combinations of asset transfer-related programming: an asset transfer of goats, the transfer in conjunction with training, or training only. The analysis finds positive effects of all three treatments on financial inclusion and women's empowerment but no effects on assets, expenditure, physical

health and food security. There is no evidence of any differential effects comparing across treatments. Another related paper found that the provision of information about the quality of livestock services had significant benefits in Pakistan (Hasanain, Khan, and Rezaee 2018).

In addition, a number of interdisciplinary papers analysing impacts of nutrition-sensitive agricultural development programmes have argued that they can have positive effects on income as well as food availability, access to food, diet quality, women's empowerment, and gender norms (Ruel, Quisumbing, and Balagamwala 2018; Heckert, Olney, and Ruel 2019; Olney et al. 2015, 2016).[4] Livestock interventions in particular have been identified as a plausible strategy to provide low-income households with potential income streams (Neumann, Harris, and Rogers 2002; Murphy and Allen 2003). However, rigorous evidence on the role of livestock market-based interventions in improving smallholder incomes – as distinct from nutritional and consumption outcomes – is largely missing (Ruel, Quisumbing, and Balagamwala 2018; Ruel and Alderman 2013). This paper seeks to provide policy-relevant evidence targeting this gap in the literature.

2 Materials and methods

2.1 Context

Poultry production is an important contributor to the agricultural economy of Burkina Faso, and it remains a major source of income and dietary inputs for large numbers of rural households (Gning 2005). Nevertheless, the focus on crop cultures such as cotton dating back to the colonial period has rendered poultry a secondary priority at the government level, with minimal investment from government research and development policies (Kondombo et al. 2003).

The poultry sector in Burkina Faso is characterised by a large proportion of smallholders, in addition to a small number of large-scale, intensive producers. Large-scale producers are concentrated in the vicinity of the two main cities, Ouagadougou and Bobo-Dioulasso. Data from the 2010 Agricultural Census shows that 99% of producers are smallholders (defined as owning a flock of between five and 50 poultry), owning 98% of the poultry flock, and producing 99% of the supply of meat and 86% of the supply of eggs (Food and Agriculture Organization 2018).

Demand for local poultry is high, reflecting potentially a preference for locally raised varieties, as well as the virtual absence of chicken imports (Schneider, Gugerty, and Plotnick 2010). Accordingly, the most significant challenge facing the poultry sector is limited supply, driven in part by the high poultry mortality experienced by smallholders. Two main diseases account for poultry mortality in this context (Newcastle disease and fowlpox), with the first more prominent and lethal. Newcastle disease follows a seasonal pattern with a peak reached during the dry season, approximately November to March (Sonaiya and Swan 2004). Although preventive vaccines against Newcastle are now available worldwide, in Burkina low adoption rates and limited access continue to be challenges (Alders and Pym 2009).

2.2 Experimental design

This evaluation was conducted in 60 rural and peri-urban communes within three targeted regions of Burkina Faso (Boucle du Mouhoun, Centre-Ouest, and Hauts-Bassins). The implementer identified 79 communes that were available for scale-up in these regions based on the following criteria: they had not previously been exposed to SELEVER pilot programming, they were identified as rural or peri-urban in the national census, and they were accessible by road year round.[5] Within this sample of eligible communes, the communes included in this evaluation were selected randomly.

The randomised design is summarised graphically in Figure 1. To minimise any imbalance in covariates, a re-randomisation procedure was implemented to assign 30 communes to the SELEVER intervention and 30 communes to the control arm. A randomisation routine selected 30 treatment communes from the sampling frame and two villages within each commune, and the routine was

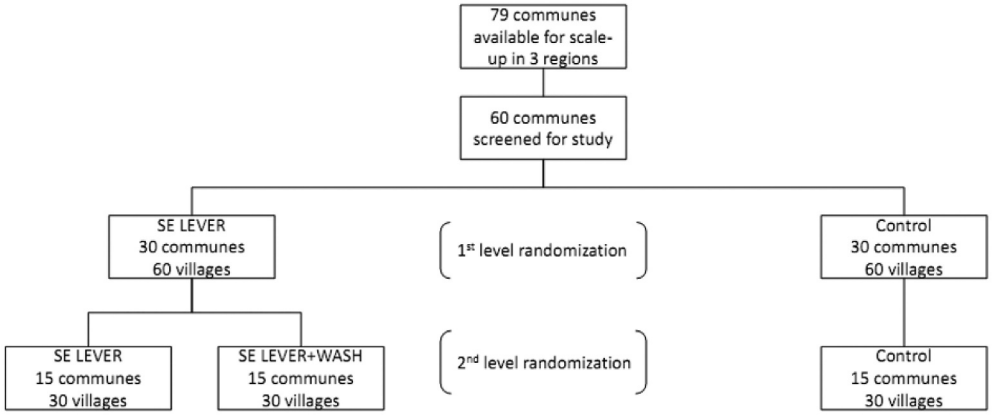

Figure 1. Evaluation design.

run with 3,000 replications.[6] The research team then selected the permutation in which the R-squared of a regression of village and commune covariates on assignment to treatment was minimised.

In sampled communities, households with a woman 15–35 years of age and a child aged 2–4 years living together were eligible for inclusion in the evaluation, provided that members provided consent for participation and did not state an intention to move out of the study area within six months post-baseline. A household census including the full community was conducted prior to the baseline to collect basic demographic variables and enable construction of the sample. In each village, 15 households were then randomly selected for inclusion, with oversampling of households identified as large poultry producers and reporting a flock size of more than 20 mature birds. This yields a target baseline sample of 1800 households in 120 villages and 60 communes in the full trial.

In the 45 communes (90 villages) that were included in the subsample targeted for additional longitudinal follow-up, 12 households were randomly selected within the 15 sample households for the additional longitudinal follow-up. The remaining three households in each village were included only in the main survey rounds. These 1080 households constitute the longitudinal subsample.

As this trial is a multidisciplinary trial incorporating nutrition and health outcomes, a full trial protocol was published (Gelli et al. 2017) that included the specification of primary and secondary outcomes, and we utilise this protocol as our reference rather than a separate pre-analysis plan. Pre-specified primary outcomes include poultry production, sales and profits, and pre-specified secondary outcomes include women's empowerment, poultry-related knowledge, use of poultry inputs, credit access and utilisation, marketing practices, and poultry mortality.[7]

Power calculations were conducted for the primary outcomes using data from a separate impact evaluation (Olney et al. 2015). In analysis of the full sample of households, estimates suggest the analysis has 80% power to detect an effect size of .18 standard deviations for household poultry production and .15 standard deviations for household poultry sales (Gelli et al. 2017).[8] Ethical approval for the evaluation was provided by the Institutional Research Board at the International Food Policy Research Institute and the Comité Éthique pour la Recherche en Santé MS/MRSI in Burkina Faso.

2.3 Intervention

The SELEVER intervention is multifaceted, reflecting the programme's broad objectives in strengthening the poultry value chain and enhancing both the supply of and the demand for nutritious food inputs (Gelli et al. 2017). In particular, it includes intervention components in three broad sectoral

areas: poultry, nutrition and health, and gender. This analysis will focus solely on the poultry intervention, and this intervention itself includes three components: training around poultry production, capacity-strengthening of village vaccination services, and enhanced access to credit.

The primary axis of SELEVER poultry programming is the provision of training to rural households, delivered via village-level producers' and savings groups.[9] They were formed or in some cases reinforced by the organisations delivering SELEVER. Eight poultry training modules were delivered by trained facilitators from the NGO partners leading SELEVER, focusing on the following topics: opportunities for income in poultry production; appropriate housing practices for poultry; poultry reproduction; chick management; best feeding practices; compiling poultry feed; poultry health; and business and entrepreneurial management for poultry production. The facilitators can be viewed as broadly similar to extension agents.

The second component of the intervention is capacity strengthening of village vaccination services. Rural poultry producers rely for extension services on a system of village vaccination volunteers (VVVs), a volunteer corps trained by government extension agents to provide basic livestock services (e.g. vaccinations, deworming, and nutrition advice). The government also bulk purchases vaccines and sells them at discounted rates to VVVs, who can then earn income on the provision of these services (Gning 2005). VVVs are active across the sample in all communities. However, the intervention provided additional training around poultry production techniques for the volunteers using the same training curriculum administered to producers, and also provided them with a basic start-up kit including a cold storage unit, a syringe and needle, and 100 doses each of poultry vaccines and deworming pills.[10] The VVVs were not constrained to provide these inputs to poultry producing households free of charge, however, and could sell or distribute them for a profit.

The third component of the intervention is enhanced access to credit for both male and female poultry producers. Two microcredit organisations collaborated with Tanager to expand into the treatment communes, providing at least one microcredit branch in each commune if such a branch was not already present. They also assumed the role of providing credit to poultry producers participating in SELEVER, but there was no explicit credit guarantee. Credit was available based on standard commercial criteria designed to identify a viable enterprise, and these criteria were largely discretionary.

2.4 Data collection

This analysis uses two primary waves of data collection: a baseline survey and endline survey of the longitudinal subsample of 1080 households (90 villages) conducted in the lean season in 2017 and 2019.[11] In each survey, sex-disaggregated data were collected on poultry production (including inputs, flock size, marketing, revenue, and profits), credit access and use of financial services, and empowerment. To collect data about poultry, questions were posed to the male member of the household who is identified to be most knowledgeable about the household's poultry activities, as well as the woman who is most knowledgeable about poultry among the women of the household. The male respondent was normally the head of household. Each respondent reported separately the number of poultry owned by type of bird and breed, and answered a series of detailed questions about poultry inputs, sales, and mortality. The reference period for the variables of interest is generally the previous six months. The respondent reported whether there was any engagement in poultry production over this period, and for poultry practices reported whether she or he engaged in that practice over this period. For variables such as input cost, revenue, and profits, the respondent reported the total amount spent or earned over this period. The only exception is flock size and the estimated value of the flock, reported as of the day of the survey.

In addition, women's empowerment was measured using the project-level Women's Empowerment in Agriculture Index (pro-WEAI), soliciting responses from the same men and women who responded to the questions related to poultry production. For the lean season survey, only data on time use and self-efficacy were collected, based on the potential for these to vary by season.

3 Empirical results

3.1 Baseline balance

In order to characterise the sample and summarise trends over time, Table 1 presents comparisons across the pooled treatment arm and the control arm in the lean season baseline, as well as the p-value corresponding to a test of equality of lean season baseline covariates across arms.[12] Again, for concision, throughout the subsequent discussion we will denote the lean season baseline and the lean season endline as simply the baseline and endline, respectively.

We first present a summary of household demographic characteristics and baseline poultry production. All monetary values are presented in real 2017 U.S. dollars. The average household includes nine members and is led by a male head of around 45 years of age. Only 7% of household heads have received some primary education, and about half of households are polygynous. Virtually all households are engaged in poultry production, reporting a flock around 30 mature birds on average at baseline. Baseline revenue (inclusive of the value of own-consumption) is around $77, and baseline profits are around $49.

In addition, Table 1 reports two variables capturing aspects of empowerment drawn from the pro-WEAI (project-level Women's Empowerment in Agriculture index): self-efficacy and work balance. Self-efficacy is a scale capturing respondents' belief in their capabilities and ability to reach their goals. Work balance is a binary variable equal to one if the respondent works fewer than 10.5 hours a day, where the workload is equal to time reported spent in the respondent's primary productive activity plus half the time reported spent in childcare as a secondary activity (Malapit et al. 2019).

The p-values for the tests of balance are reported in Column (3) of Table 1, and generally suggest that the hypothesis that covariates are balanced across arms cannot be rejected. The Table also reports the p-value corresponding to a joint F-test of balance across all covariates reported, and again the hypothesis of balance cannot be rejected.

Table 1. Summary statistics across arms: baseline.

	(1) Baseline Control arm	(2) Baseline Treatment arm	(3) Balance test p-value
Age household head	43.78	44.622	.185
Any primary education (household head)	.086	.054	.009
Household size	9.054	8.97	.574
Polygynous	.480	.498	.243
Any poultry	.977	.982	.218
Number mature birds	30.108	29.031	.89
Stock value	122.201	118.478	.725
Any poultry revenue	.697	.703	.841
Any egg revenue	.131	.106	.752
Poultry revenue	77.115	66.998	.735
Egg revenue	1.24	.923	.897
Poultry profits	49.044	42.643	.896
Self-efficacy: men	.624	.608	.815
Work balance: men	.74	.745	.801
Self-efficacy: women	.495	.48	.786
Work balance: women	.229	.244	.678
Joint-test p-value	.108		

This table reports key indicators of interest corresponding to household demographics, poultry production, and gender norms as observed at baseline in communes assigned to the control and treatment arms. Column (3) reports the p-value corresponding to a regression in which the indicator of interest at baseline is regressed on a binary variable for assignment to SELEVER; the regression is weighted to take into account baseline sampling probabilities, and standard errors are clustered at the commune level. At the bottom of the Table we report a joint p-value corresponding to a F test across all outcomes analysed.

3.2 Intervention exposure

Table 2 reports a series of variables capturing exposure to the SELEVER intervention for households assigned to the control and treatment arms. Column (7) reports a p-value corresponding to a test of equality across treatment and control arms.[13] On average, about 30% of all households in SELEVER communities report that they have benefited from the SELEVER intervention; there is some evidence of contamination in the control arm, as 14% of households report benefits, but the difference in exposure is clearly significant.

Similarly, about half of households surveyed report they attended at least one training around poultry, and attendance is relatively balanced by gender. 37% of households report at least one woman attended the training, and 43% of households report at least one man attended the training. The total number of trainings attended in aggregate by the household is around 2.6, relative to eight total modules administered. Attendance at business-oriented trainings was somewhat lower (around 28%), but again balanced for men and women. Reported household participation in poultry producers' groups, the fundamental platform for the SELEVER intervention, is lower relative to inclusion in trainings; 24% of households report that they are a member of a producer group, and again roughly equal numbers report that at least one male (female) member is a member of the group. The final row of the Table reports engagement with the village-level VVVs. Here, even the control group reports that nearly 70% of households know at least one VVV, but this increases to 81% in treatment communities.

In order to capture a summary measure of intervention exposure given the programme's diverse facets, we also report a variable capturing any exposure, equal to one if the household reports any benefits from SELEVER; attended a poultry training; attended a business training; or is a member of a producers' group. Knowledge of the VVV is excluded from this measure given that the VVV system is not an innovation introduced by SELEVER. Using this measure, around 60% of households in intervention communities reported some exposure to the poultry-related interventions rolled out, while 20% of households in control communities reported similar exposure.

Table 2. Summary statistics for SELEVER exposure in treatment communities.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Control arm			Treatment arm			
Indicator	Mean	St. dev.	Obs.	Mean	St. dev.	Obs.	p-value
Household reports benefits from SELEVER	.02	.14	346	.27	.44	664	.000
Any member attended poultry training	.12	.32	346	.49	.5	664	.000
Attendance at poultry training: female	.06	.24	313	.37	.48	637	.000
Attendance at poultry training: male	.09	.29	298	.43	.49	564	.000
Number of trainings attended (all members)	1.2	.76	38	2.63	3.02	313	.000
Any member attended business training	.11	.31	346	.29	.45	664	.000
Attendance at business training: female	.08	.27	313	.21	.41	637	.001
Attendance at business training: male	.05	.23	298	.21	.41	564	.000
Any member participates in producers' group	.04	.2	346	.24	.43	664	.000
Participation in group: female	.02	.15	313	.17	.37	637	.000
Participation in group: male	.03	.16	298	.2	.4	564	.000
Any member knows VVV	.67	.47	346	.81	.39	664	.006
Any reported exposure to SELEVER programming	.20	.40	346	.57	.5	664	.000

This table reports summary statistics (mean, standard deviation, and number of observations) for variables capturing programme exposure as observed in the lean season endline for individuals in the control and treatment arms. Column (7) reports the p-value corresponding to a regression in which the indicator of interest is regressed on a binary variable for assignment to SELEVER; the regression is weighted to take into account baseline sampling probabilities, and standard errors are clustered at the commune level.

4 Results

4.1 Main specification

The primary specification of interest is an ANCOVA specification that exploits the randomised design. More specifically, outcome variables $Yivc, t$ for household i in village v, commune c and time period t are regressed on a dummy variable S_{vc} capturing whether the commune is assigned to the treatment arm, as well as the baseline level of the outcome variable $Yivc, t-1$ and household covariates $X^{ivc,t-1}$.[14]

$$Y^{ivct} = \beta 1 Svc + \beta 2 Y^{ivc,t-1} + X^{ivc,t-1} + \in^{ivct} \quad (1)$$

Period t refers to the endline, and period t-1refers to the baseline. Standard errors are clustered at the level of the commune, and the regression is weighted using the probability of selection to account for the over-sampling of large producers.

Given that the sample includes 45 communes (30 treated communes), we also report alternate p-values estimated using the wild bootstrap to adjust for any bias due to the relatively low number of clusters.[15] In addition, for primary and secondary outcomes, we report q-values corrected for multiple hypothesis testing, using the Simes method (Newson 2010). This correction is implemented for the four primary outcomes (Panel A of Table 3), for the set of ancillary variables reported in Panel B of the same table, and for each family of secondary outcomes (Tables 4 and 5).

4.2 Primary outcomes

Table 3 reports the effects for the main outcomes, estimating equation (1). Primary outcomes pre-specified in the protocol were poultry production defined as total stock value, revenue as well as total revenue (inclusive of the value of own-consumption), and profits, reported in Panel A. (Profits is defined as the difference between total revenue inclusive of the value of own-consumption and total input costs.) It is evident in Column (1) that there is no significant increase in total stock value. However, we observe in Column (2) an increase in the level of revenue that is significant at the five percent level and fairly substantial in magnitude. Revenue increases by $11.42 relative to a mean of $37.86, an increase of 30%. Revenue is coded as zero for households that did not report any poultry sales. In Column (3), we estimate a parallel specification for a measure of total revenue (inclusive of the value of own consumption), and again we observe a significant and positive coefficient that is even larger in magnitude, indicating an increase of 34% relative to the mean.[16] Both coefficients are significant at the five percent level using wild bootstrap p-values, and at the ten percent level using q-values corrected for multiple hypothesis testing.

Despite the positive effects on revenue, there is no meaningful effect on household profits, calculated as total revenue (inclusive of the value of own-consumption) minus total costs. The coefficient reported in Column (4) is positive, but relatively small in magnitude ($9 or around 23%) and statistically insignificant.

Panel B reports ancillary variables that capture alternate dimensions of poultry production and revenue in order to explore the robustness of these results. These additional variables were not pre-specified. Columns (1) and (2) confirm that there is no significant shift in poultry production as measured by the probability of reporting any poultry owned or the number of mature birds owned. There is no shift in the probability of reporting any revenue from poultry production in Column (3), suggesting that the previously reported effect is only along the intensive margin, rather than the extensive margin. In addition, there is no evidence of any shift in revenue from egg production, as reported in Columns (4) and (5).

Given that one important objective of SELEVER is to increase women's engagement in and decision-making around poultry production, we also re-estimate this specification for a series of variables capturing women's empowerment (self-efficacy, work balance, and gender norm attitudes).

Table 3. Effect of SELEVER on household poultry production: primary outcomes.

	(1)	(2)	(3)	(4)	(5)
Primary outcomes					
	Stock value	Revenue	Revenue + cons. value	Profit	
SELEVER	10.860	11.417	17.187	9.439	
	(11.624)	(5.014)	(6.531)	(6.870)	
Bootstrap p-value	[.398]	[.038]	[.020]	[.208]	
Mult. hypo. q-value	[.216]	[.055]	[.050]	[.216]	
Mean control arm	108.874	37.864	49.644	39.562	
St. dev. control arm	103.904	57.091	67.708	115.848	
Obs.	999	999	999	999	
Robustness: Ancillary measures linked to primary outcomes					
	Any poultry	Number mature Birds	Any revenue	Any revenue Eggs	Egg Revenue
SELEVER	.019	3.330	.027	−.0002	−.286
	(.029)	(2.652)	(.051)	(.041)	(.352)
Bootstrap p-value	[.597]	[.238]	[.599]	[.997]	[.475]
Mult. hypo. q-value	[.752]	[.752]	[.752]	[.996]	[.752]
Mean control arm	.96	25.754	.72	.149	1.147
St. dev. control arm	.196	22.59	.45	.356	3.563
Obs.	999	999	999	999	999

This table reports results for the primary outcomes of interest. The dependent variables are regressed on a binary variable for assignment to SELEVER, the baseline level of the dependent variable, and demographic controls; the regression is weighted to take into account baseline sampling probabilities, and standard errors are clustered at the commune level. P-values estimated using the wild bootstrap are reported in brackets. The reference period for variables is generally the past six months. The variables of interest are as follows: the estimated value of the flock on the day of the survey, revenue from poultry sales, total revenue (including cash from poultry sales and the imputed value of poultry consumption), total profits, a binary variable for any poultry reported raised by the household over the reference period, the number of mature birds owned on the day of the survey, a binary variable for any reported revenue from poultry sales, a binary variable for any reported revenue revenue from egg sales, and the total amount of egg revenue. Monetary variables are reported in real 2017 U.S. dollars. Asterisks indicate significance at the ten, five and one percent level.

As reported in Table A1 in the Appendix, we see no evidence of any effects for men or women. Accordingly, we conclude that there is no robust evidence that the intervention affected women's empowerment more broadly.[17]

4.3 Secondary outcomes

Tables 4 and 5 report experimental effects for additional secondary outcomes of interest, also pre-specified in the protocol (Gelli et al. 2017). In Table 4, Panel A reports variables around poultry practices. Column (1) reports regression results for a simple knowledge index, created by aggregating the respondent's (binary) responses to a series of nine questions about appropriate poultry practices. Column (2) reports the cost of poultry inputs. Columns (3) through (7) report a series of binary variables capturing poultry practices: whether poultry are vaccinated, fed cereals, fed concentrate, provided deworming medications, and confined in a poultry henhouse (rather than ranging free).

The results suggest that households in the SELEVER communities report a weakly significant increase in the knowledge index: the number of questions answered correctly increases by .04 on a mean of .63. Again, the mean score corresponds to the average number of (binary) questions to which the respondent provides the correct response. Column (2) suggests that there is a substantial increase in reported input costs ($6.41 relative to a mean of $13.45 in the control arm).[18] Moreover, the increased expenditure on inputs is consistent with the observed increase in vaccination, concentrate feeding, and deworming reported in Columns (3) through (7), and the shift in the probability of utilising these practices is proportionately large: an increase of between eight and 11 percentage points relative to a mean probability in the control arm of 52% for any vaccination, 10% for concentrate feeding and 21% for deworming.[19] These effects are observed to

Table 4. Effect of SELEVER on secondary outcomes.

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
Panel A: Poultry practices							
	Poultry Knowledge index	Input Cost	Any Vaccination	Fed Poultry cereals	Fed Poultry concentrate	Any Deworming	Poultry Confined
SELEVER	.043	6.412	.087	.002	.108	.078	.039
	(.023)	(1.803)	(.041)	(.033)	(.025)	(.035)	(.034)
Bootstrap p-value	[.073]	[.001]	[.049]	[.931]	[.001]	[.050]	[.253]
Mult. hypo. q-value	[.098]	[.006]	[.054]	[.908]	[.000]	[.054]	[.302]
Mean control arm	.632	13.446	.52	.969	.104	.211	.08
Obs.	938	1007	943	943	943	943	1007
Panel B: Financial services							
	Any Deposit	Amount Deposited	Any Loans Accessed	Total Loans	Num. Credit Groups	Num. Credit-related org.	
SELEVER	.040	13.487	.052	.139	.047	.197	
	(.051)	(6.799)	(.063)	(.126)	(.200)	(.368)	
Bootstrap p-value	[.431]	[.053]	[.413]	[.348]	[.536]	[.558]	
Mult. hypo. q-value	[.634]	[.253]	[.634]	[.634]	[.763]	[.714]	
Mean control arm	.271	77.692	.217	.120	.600	.500	
Obs.	1007	1007	1007	1007	88	89	
R_2	.014	.022	.009	.017	.005	.006	

This table reports results for the secondary outcomes of interest, and the specification is identical to that described in Table 3. P-values estimated using the wild bootstrap are reported in brackets. The reference period for all variables is the past six months. The variables of interest are as follows. In Panel A, Column (1) analyzes an index of poultry-related knowledge; Column (2) analyzes total reported expenditure on poultry inputs over the past six months; and Columns (3) through (7) analyse a series of binary variables capturing whether the household has engaged in the specified practice over the previous six months. In Panel B, Column (1) analyzes a binary variable for whether the household reports any deposit over the previous six months; Column (2) analyzes the amount reported deposited over the previous six months; Columns (3) and (4) analyse whether the household reports any access to credit, and the amount of credit accessed. Columns (5) and (6) report village-level regressions in which the dependent variables are the number of credit groups and the number of credit-related organisations. Asterisks indicate significance at the ten, five and one percent level.

be consistently statistically significant using both the wild bootstrap-corrected p-values and the multiple hypothesis-corrected q-values, though the increase in vaccination is only significant at the ten percent level.

Panel B in the same Table reports variables linked to use of financial services: whether the household reports any deposits in a savings institution in the last six months, the amount reported deposited in the same period, and whether the household reports any loans and the amount of the loan. Two variables linked to the supply of financial services at the village level are also reported: the number of credit groups, and the number of organisations promoting access to credit in the village. In general, there is little evidence of any significant effect on use of financial services or use of credit. There is some noisy evidence of an increase in the amount deposited, corresponding to an increase of 17% relative to the control arm, but this effect is insignificant when multiple hypothesis-corrected q-values are employed. There is no increase in utilisation of or supply of credit. These results are also consistent with findings from a parallel qualitative study that reported minimal effects of the intervention on credit access (Eissler et al. 2020).

Table 5 reports variables linked to poultry marketing and poultry mortality and consumption. In Panel A, Columns (1) and (2) report the number of birds sold and the estimated price (the product of these two variables is revenue). Columns (3) through (5) report binary variables for whether the household reports selling poultry at home, at a market, and door to door. It is evident that the treatment households report a substantial increase in the number of poultry sold (an additional two birds relative to nine birds in the control arm, for a proportional effect of over 25%).[20] The effect on price is positive but small in magnitude and insignificant, and there is no evidence of a shift in sale locations. This suggests that households are not responding to the intervention by accessing new commercialisation opportunities.

Table 5. Effect of SELEVER on poultry marketing, mortality and consumption.

	(1)	(2)	(3)	(4)	(5)	(6)
	Number Sold	Price	Sell Home	Sell Market	Sell Door	
Panel A: Poultry Marketing						
SELEVER	1.994	.093	.034	−.025	.023	
	(.861)	(.181)	(.080)	(.050)	(.034)	
Bootstrap p-value	[.062]	[.550]	[.599]	[.816]	[.592]	
Mult. hypo. q-value	[.321]	[.753]	[.753]	[.974]	[.753]	
Mean control arm	9.017	4.342	.329	.314	.029	
Obs.	1007	486	1007	1007	1007	
R_2	.208	.049	.047	.146	.004	
Panel B: Poultry Mortality and Consumption						
	Number Lost	Any Loss	Mortality Ratio	Number Consumed	Any Consumed	Total flock Size
SELEVER	.763	.042	−.062	1.010	.050	4.621
	(5.620)	(.048)	(.160)	(.419)	(.055)	(4.436)
Bootstrap p-value	[.912]	[.432]	[.360]	[.028]	[.425]	[.299]
Mult. hypo. q-value	[.885]	[.640]	[.755]	[.131]	[.640]	[.640]
Mean control arm	39.289	.771	1.291	2.586	.52	47.634
Obs.	1008	1008	900	1008	1008	1008

This table reports results for the secondary outcomes of interest, and the specification is identical to that described in Table 3. P-values estimated using the wild bootstrap are reported in brackets. The reference period for all variables is the past six months. The variables of interest are as follows. In Panel A, Column (1) analyzes the number of poultry sold over the last six months, and Column (2) analyzes the price; Columns (3) through (5) analyse binary variables for reported sales in the specified location. In Panel B, the variables of interest are as follows: the number of poultry reported lost due to mortality over the last six months; a binary variable for any poultry reported lost; the mortality ratio (the number of poultry reported lost divided by the number owned as of the survey date); the number of poultry reported consumed over the last six months; a binary variable for any poultry consumed; and the total flock size (including chicks) as of the survey date. Monetary variables are reported in real U.S. dollars. Asterisks indicate significance at the ten, five and one percent level.

Panel B reports variables capturing poultry mortality over the past six months and the number of poultry reported consumed. There is no evidence that households exposed to SELEVER report lower poultry losses, in absolute terms, using a binary variable for any losses, or when losses are normalised with respect to the present flock, as reported in Columns (1) through (3).[21] Treatment households do report more own-consumption in Column (4), though this effect is not significant when using the multiple hypothesis-corrected q-values. In Column (5), we confirm that there is no treatment effect on total flock size, including chicks.

5 Discussion

In interpreting these results, it is useful to start with the question of the return to inputs. Households exposed to SELEVER programming have meaningfully increased their use of poultry inputs; what is the realised return? There is no evidence of any direct effect on flock size or flock value. However, the results previously presented suggest that households in the treatment arm are consuming and selling more poultry over the past six months, a period from roughly April to September in the calendar year. They report no reduction in losses over the past six months, but as of the survey date report flock sizes that are on average comparable to or weakly greater than households in the control arm. These patterns are prima facie incompatible, but could be consistent with two possible hypotheses.

The first hypothesis is that households are not reporting the changes in their poultry inventory accurately. To render the estimates compatible, control (treatment) households would have to be systematically underestimating (overestimating) their poultry losses or their poultry consumption. The second hypothesis is that treatment households expanded their flocks prior to the recall period, and then sold and consumed more over the six months immediately prior to the survey, converging to a flock size similar to those observed among control households. Note that input use was also reported only for the past six months, but presuming there is some serial correlation in this measure, treatment households may also have used inputs more intensively in prior periods, and would have realised any positive returns to these inputs. In this case, there would need to be some pronounced seasonality in the mortality returns to inputs, such that these returns are observed primarily outside the recall period of April to September.

Evidence around the seasonality of poultry disease is limited. Global reviews have highlighted that Newcastle disease in particular has seasonal outbreaks (Awan, Otte, and James 1994), and the dry season is identified as a higher risk period (Sonaiya and Swan 2004; Abalaka, Mkpado, and Ugwu 2013; Awuni 2002). In Burkina Faso, the dry season is generally identified as December through March (USAID 2017). If mortality from diseases targeted by vaccines is highest in this period, then mortality effects may not have been evident during this survey's reporting period.[22] In general, it seems reasonable to conclude that treatment households did benefit from some positive returns to the poultry inputs employed in reducing mortality, such that they could sell and consume more chickens and still report a similar flock size. However, this hypothesis must remain speculative.

Shifting to the observed effects on revenue, correlational evidence suggests that it is in fact households who are increasing their use of inputs who are simultaneously increasing their revenue: the correlation between input use and reporting any poultry revenue is positive in the control arm, but positive and significantly larger in magnitude in the treatment arm, suggesting that the intervention is encouraging a subset of responsive households to simultaneously increase input use and sales. However, these households do not command a higher price for their poultry. Again, this pattern would be consistent with multiple interpretations. It may be that the return to inputs is observed only in flock size growth – again, seemingly primarily outside the recall period – and there is no effect on observable quality that can be rewarded in the market. It may be that the use of inputs such as concentrate feeds does increase the number of chickens who meet some minimal quality threshold rendering them suitable for sale in the market, but conditional on passing this threshold,

these marginal chickens do not command a higher price. Alternatively, there may be some effect on quality that is unobservable in the market, or an effect on quality that is captured by intermediaries or traders rather than the selling household.

6 Conclusion

This article provides new evidence about the effects of a multifaceted intervention, SELEVER, providing poultry-related training and capacity-building for village-level veterinary and credit institutions and evaluated in a randomised controlled trial in Burkina Faso. The empirical evidence suggests that the intervention was successful in engaging households in training and poultry producers' groups, and stimulated an increase in the use of poultry inputs and an increase in the commercialisation of poultry (the number of poultry sold) and revenue. However, there is no evidence of an increase in profits.

A growing literature analyzes interventions targeting enhanced livestock production in developing countries, and the majority of this literature has analysed programmes in which households receive an actual transfer of livestock, with or without additional training or services. In general, these interventions have shown large positive effects on household economic welfare, but there is very little evidence around programmes that provide only training and other services targeting a strengthened value chain. Evidence here suggests that the positive effects of training only interventions may be small. Future research may benefit from exploring in more detail the barriers limiting poor households' engagement in livestock production, in particular high observed mortality and an inability to transition to larger-scale production.

Notes

1. Additional dimensions of the SELEVER intervention not analysed in this paper included behavioural change communication around nutrition and health designed to promote improved diets and nutritional status for women and children; and community-level sensitisation around women's economic empowerment.
2. The full evaluation sample included 120 villages in 60 communes, but this analysis focuses on a subsample targeted for more detailed longitudinal tracking, and selected using a second-level randomisation within the main sample (described in more detail below).
3. One target village was not surveyed at baseline and thus was never enrolled into the evaluation, as another village with a similar name was surveyed in error. Data from the village surveyed in error is excluded from analysis.
4. A nutrition-sensitive agricultural intervention is defined as an intervention that seeks to 'address underlying determinants of foetal and child nutrition and development – food security; adequate caregiving resources at the maternal, household and community levels; and access to health services and a safe and hygienic environment – and incorporate specific nutrition goals and actions.' See Ruel and Alderman (2013) for more details.
5. For the Hauts-Bassins region, an additional criterion was proximity to the other two intervention regions.
6. Villages that did not have the target population size for the intervention were excluded from the list. On the one hand, villages projected to have fewer than 15 households with children in the two to four year old range (based on the population of women of reproductive age and age-specific fertility rates from the latest Demographic and Health Survey) were not eligible for inclusion in the evaluation. On the other hand, villages with population over 5000 were not considered to be rural, and were similarly ineligible.
7. Table 3 in the published trial protocol provides full details.
8. This is assuming an intracluster correlation of .001 at the level of the commune and between .05 and .1 at the level of the village. Data employed for power calculations was drawn from two observational studies evaluating food intake in the study regions, and a recent impact evaluation of the Helen Keller International homestead food production intervention (Arsenault et al. 2014; Martin-Prevel et al. 2016; Olney et al. 2016).
9. These groups are known as Mutuelles de Solidarité, MUSOs, or Solidarity Groups, GS.
10. The intervention also aimed to develop a cohort of women VVVs to better reach women poultry producers.
11. Limited data will be drawn from an earlier baseline survey conducted in a different season (the post-harvest season), and including all 1800 households in 120 villages.
12. More specifically, baseline covariates are regressed on a treatment dummy, with standard errors clustered at the commune level. The regression is weighted to take into account household-level oversampling of large producers.

13. We report the p-value from a regression in which the indicator of interest is regressed on a binary variable for assignment to SELEVER; the regression is weighted to take into account sampling probabilities and standard errors are clustered at the commune level.
14. The household covariates include household size, the age of the head of household, and the baseline flock size (number of mature birds).
15. Cameron, Gelbach, and Miller (2008) suggests that overrejection can arise when the number of clusters is between five and thirty, suggesting that this case is marginal in terms of the magnitude of the bias. To estimate the wild bootstrap p-values, we utilise the Stata command boottest (Roodman, 2019).
16. The value of own consumption is calculated imputing a price for each poultry consumed calculated as the mean of sales prices reported for poultry in that commune.
17. As noted above, we analyse self-efficacy and work balance as measured in the pro-WEAI; the number of minutes reported engaged in childcare, work, and non-work activities given the importance of the respondent's work burden in a context of a project targeting increased engagement in poultry; and a gender norm attitudes scale, coded such that a higher value corresponds to more support for gender equity (Waszak et al. 2001; Nanda 2011).
18. Further exploration allows us to identify that this increase in input costs is driven solely by increase in inputs purchased (as opposed to poultry purchased to enlarge the flock).
19. In addition to feeding practices, data was also captured on whether the poultry were provided water at will. However, 95% of households in the control group report that they provide water at will, and thus unsurprisingly no experimental effect was observed on this outcome.
20. This coefficient is narrowly insignificant at conventional levels when multiple hypothesis-adjusted q-values are employed.
21. Mean reported poultry losses are extremely high – a mean of 35 and a median of 16 – relative to reported total flock size as of the survey date, characterised by a mean of 49 and median of 38. The distribution of reported poultry losses is characterised by significant outliers, evident in the larger gap between mean and median; this pattern is consistent with the hypothesis that large producers are particularly vulnerable to large-scale epidemics in which a large number of poultry are lost.
22. It is also important to note that returns to vaccine use may be low if vaccines are not deployed appropriately: prior to the arrival of the disease, using an appropriate dosage and a nonexpired and appropriately refrigerated vaccine. If vaccine services provided by the VVV do not meet these criteria, limited effects on mortality are unsurprising, and in fact adverse effects would also be possible (Dimitrov et al. 2017).

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Notes on contributors

Jessica Leight is a research fellow in the Poverty, Health, and Nutrition Division of the International Food Policy Research Institute (IFPRI), Washington, DC.

Josué Awonon was previously a research analyst in the Poverty, Health, and Nutrition Division of IFPRI, and is now a PhD student in Economics and Public Policy at Tufts University.

Abdoulaye Pedehombga is a researcher with AFRICSanté.

Rasmané Ganaba is the executive director of AFRICSanté.

Elena M. Martinez is a doctoral student at the Friedman School of Nutrition Science and Policy at Tufts University, and was previously a senior research analyst at the CGIAR Research Program on Agriculture for Nutrition and Health led by IFPRI.

Jessica Heckert is a research fellow in the Poverty, Health, and Nutrition Division of IFPRI.

Aulo Gelli is a senior research fellow in the Poverty, Health, and Nutrition Division of IFPRI.

ORCID

Jessica Leight http://orcid.org/0000-0002-1691-9682
Jessica Heckert http://orcid.org/0000-0002-3022-8298
Aulo Gelli http://orcid.org/0000-0003-4977-2549

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Appendix: For online publication only

Table A1. Effect of SELEVER on gender norms.

	(1)	(2)	(3)	(4)	(5)	(6)
	Self Efficacy	Work Balance	Childcare Time	Work Time	Non-work Time	Gender norms Scale
Panel A: Gender norms reported by men						
SELEVER	.018	.014	−.216	−14.564	−.476	−.226
	(.055)	(.040)	(28.897)	(24.096)	(28.782)	(.368)
Obs.	787	747	747	791	747	799
$_{R2}$	.038	.029	.044	.023	.044	.038
Panel B: Gender norms reported by women						
SE LEVER	.040	−.078	−.402	75.312	−8.538	−.575
	(.061)	(.053)	(28.168)	(68.377)	(33.715)	(.336)
Obs.	888	863	882	888	882	947
R_2	.01	.028	.003	.038	.006	.029

This table reports results for the primary outcomes of interest, and the specification is identical to that described in Table 3. P-values estimated using the wild bootstrap are reported in brackets. The dependent variables are as follows: Columns (1) and (2) analyse self-efficacy and work balance as measured in the pro-WEAI index. Columns (3) through (5) analyse the number of reported minutes engaged in childcare, in work, and in non-work activities. Column (6) analyzes a gender norm attitudes scale, in which a higher value corresponds to more support for gender equity. Asterisks indicate significance at the ten, five and one percent level.