INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

IFPRI

CGIAR

RESEARCH PROGRAM ON Agriculture for Nutrition and Health

Led by IFPRI

CGIAR

RESEARCH PROGRAM ON Policies, Institutions, and Markets

Led by IFPRI

**IFPRI Discussion Paper 02072**

December 2021

# Understanding the Role of Different Program Components of a Nutrition Sensitive Intervention in Mediating Impact

## Applying Causal Mediation Analysis to Experimental Evidence from Burkina Faso

Jessica Heckert

Jessica Leight

Josué Awonon

Aulo Gelli

Poverty, Health, and Nutrition Division

## INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE

The International Food Policy Research Institute (IFPRI), a CGIAR Research Center established in 1975, provides research-based policy solutions to sustainably reduce poverty and end hunger and malnutrition. IFPRI's strategic research aims to foster a climate-resilient and sustainable food supply; promote healthy diets and nutrition for all; build inclusive and efficient markets, trade systems, and food industries; transform agricultural and rural economies; and strengthen institutions and governance. Gender is integrated in all the Institute's work. Partnerships, communications, capacity strengthening, and data and knowledge management are essential components to translate IFPRI's research from action to impact. The Institute's regional and country programs play a critical role in responding to demand for food policy research and in delivering holistic support for country-led development. IFPRI collaborates with partners around the world.

## AUTHORS

Jessica Heckert (j.heckert@cgiar.org) is a Research Fellow in the Poverty, Health, and Nutrition Division at the International Food Policy Research Institute (IFPRI), Washington, DC.

Jessica Leight (j.leight@cgiar.org) is a Research Fellow in IFPRI's Poverty, Health, and Nutrition Division, Washington, DC.

Josué Awonon (awononjosue@yahoo.fr) is a PhD Student at Tufts University, Medford, MA.

Aulo Gelli (a.gelli@cgiar.org) is a Senior Research Fellow in IFPRI's Poverty, Health, and Nutrition Division, Washington, DC.

# Abstract

In complex nutrition-sensitive interventions, separately identifying the effect of each programmatic component on the outcomes of interest can be challenging. This paper examines the relationship between participation in different elements of the nutrition-sensitive intervention SELEVER, implemented in rural Burkina Faso with the objective of increasing poultry production and enhancing related nutritional outcomes, and women's poultry production. We use structural equation modeling to estimate the direct effect of each component of program participation. Our findings suggest that respondents' directly reported participation in SELEVER intervention activities mediates less than half of the observed intervention effects on poultry owned by women as well as women's revenue and profits from poultry production. Accordingly, other indirect channels for program effects also seem to be important.



**Keywords:** poultry production, gender, structural equation modeling

# Acknowledgments

We would like to thank Marie Ruel, Harold Alderman, Agnes Quisumbing, Deanna Olney, Shalini Roy, Giordano Palloni, Jef Leroy, and the Tanager team in Ouagadougou for their input and feedback on the study design. We acknowledge funding support for the overall trial from the Bill & Melinda Gates Foundation (grant no. OPP1149709) and the CGIAR Research Program on Agriculture for Nutrition and Health (A4NH), led by IFPRI (sub-grant no. A4NH- 202004.040.500); we would also like to acknowledge support from the CGIAR Research Program on Policies, Institutions and Markets for this analysis.

## I. Introduction

In recent years, the literature analyzing complex and multifaceted interventions targeting outcomes linked to agriculture, nutrition and gender has grown rapidly (Gillespie & van den Bold, 2017; Masset et al., 2012; Mayne & Johnson, 2015; Ruel & Alderman, 2013). Many of these interventions are evaluated using randomized controlled trials or other rigorous evaluation methods, but given their complexity, an evaluation usually entails comparing the full set of interventions vis-à-vis a control arm that receives no or minimal services. This raises the question of what role each intervention component plays in generating the outcomes of interest. While more complex trial designs can provide useful evidence along these lines, the sample size and resources that would be required to separately evaluate each element of a complex intervention can be substantial.

This paper analyzes a complex intervention, Soutenir l'Exploitation Familiale pour Lancer l'Élevage des Volailles et Valoriser l'Économie Rurale (SELEVER), implemented in rural Burkina Faso with the objective of enhancing poultry production and improving the nutritional status of women and children. The program entails two primary components (poultry and nutrition/gender) and each component itself includes a range of intervention activities. Trainings were conducted on poultry husbandry and nutrition and gender, village-level groups were formed or strengthened as a platform for training (in the case of poultry, these were poultry producers' groups), and home visits were conducted focusing on poultry vaccination and husbandry, as well as enhanced nutrition and gender practices. The intervention was also analyzed in a large-scale randomized controlled trial that entailed tracking a sample of approximately 1,600 households in 119 communities over three years (Gelli et al., 2017). The primary trial effects for poultry production show generally null effects on household-level measures of poultry but a significant and positive increase in women's reported poultry production, at the expense of jointly owned poultry production (Leight, Awonon, Pedehombga, Ganaba, & Gelli, 2021; Leight, Awonon, Pedehombga, Ganaba, Martinez, et al., 2021). (The definition of jointly owned is poultry that are viewed as a shared asset collectively owned by men and women.)

The objective of this paper is to examine the relationship between participation in various dimensions of SELEVER's multifaceted programming and the increase in poultry owned, revenue and profits observed for women in treatment communities. We use structural equation modeling (SEM) to identify the contribution of each element of program participation to the overall intervention effect. SEM allows us to quantify the extent to which the intervention effects we see are mediated by specific measured dimensions of program participation. This provides valuable evidence around the role of each program component in shifting overall dynamics in poultry production, and thus allows us to further unpack the program impact pathways even in the framework of an evaluation of a complex intervention.

The primary intervention findings from the SELEVER trial, already published, suggest that the intervention was effective in shifting some poultry practices at the household level (encouraging households in treatment communities to invest more in poultry inputs, and perhaps lowering mortality), but did not generate a positive effect on the overall level of poultry revenue or profits (Leight, Awonon, Pedehombga, Ganaba, & Gelli, 2021). There were also no meaningful effects on nutritional or gender empowerment outcomes. There is, however, some evidence of an intrahousehold shift in poultry production in which women report higher levels of poultry ownership and more revenue and profits from poultry, and poultry production in the jointly owned category shrinks. These effects are not large in absolute magnitude, but they are large relative to the baseline level of poultry production for women:

Women in SELEVER communities report at endline on average one more chicken owned, relative to a mean of two in the control arms, and report increases in revenue and profits of around a dollar at endline, relative to a mean of between three and four dollars in the control arm.

Here, the results from our SEM analysis suggest that in fact respondents' directly reported participation in SELEVER intervention activities mediates less than half of the observed intervention effects in these domains of women's poultry production; depending on the precise outcome of interest, between 30% and 40% of the outcome is mediated by program participation. The only program dimension that is consistently identified as a positive and significant mediator of the treatment effect is the receipt of extension services from village vaccinators, a corps of animal health service providers who are present in all communities but received some capacity strengthening through SELEVER. As a mediating variable, SELEVER poultry programming is estimated to be positive but statistically insignificant, and the estimated coefficient for nutrition and gender programming is negative for poultry outcomes.

These findings would be consistent with several interpretations. One is that self-reported participation is not a fully accurate proxy for household's real engagement with the intervention; or, alternatively, households who currently do not report participation had previously participated, and there were some lagged positive effects of their engagement. A second is that there are also substantial indirect effects of SELEVER, via informational spillovers or other local-level shifts, and because of these effects, the share of the overall intervention impact mediated by specific dimensions of program participation is not high. A third possible interpretation is that the intervention was not sufficiently intensive to substantially shift the behavior of households who directly participated. The evidence presented in this study is also suggestive of potential trade-offs between the agriculture, nutrition and gender programming that will require further investigation.

This paper proceeds as follows. The second section provides an overview of the intervention. The third section describes the empirical methods and the results. The final section discusses and concludes.

## II. Program description

SELEVER, or the Women's Poultry Program to Improve Income and Nutrition project is a five-year program implemented by Tanager in partnership with local NGOs, private institutions, and governmental services and funded by the Bill & Melinda Gates Foundation. SELEVER aims to increase poultry production and improve the nutritional status of women and children in the Centre Ouest, Hauts-Bassins, and Boucle de Mouhoun regions of Burkina Faso. It is comprised of two complementary components: one on poultry production and marketing, the other on nutrition and gender.

### A. Description of poultry production and marketing component

This component included vaccinations, financing and training on poultry flock management and housing. The community-level activities included training, advocacy, and follow-up monitoring. Training materials include guideline manuals and videos developed by Tanager. The community-level rollout also had some features specific to implementing NGOs. In one area, interested producers were identified and organized into groups called Mutuelles de Solidarité (MUSO). In another area, interested producers were organized in Solidarity Groups (GS). Each MUSO had 15 to 30 members and there were approximately 7 MUSOs in each village. Each GS consisted of up to 15 people (both women and men) interested in breeding, and there were approximately 10 GS per village. Each group appointed a

president and a treasurer. In each village there were about 10 GS. Beneficiary groups were then trained by the NGO facilitators on all the SELEVER poultry modules. The facilitators also monitored credit use and poultry production practices at the beneficiary level. Facilitators were also subsequently trained on gender and nutrition package so that they could incorporate these dimensions into their activities.

Village-level vaccinators (VVVs), who are present throughout the treatment and control areas, are key community-level actors in the implementation of the SELEVER poultry component. VVVs are identified by the livestock services and trained on vaccination and poultry husbandry. After their training, they offer follow-up vaccination services, poultry deworming and nutritional advice to the beneficiaries; these services are offered for a fee. Additionally, government representatives from livestock extension services, the Direction régionale des ressources animales et halieutiques, provides technical support through the training and monitoring of VVVs, support to NGO facilitators for poultry trainings, market facilitation, and maintaining VVVs' supply of vaccines and other livestock inputs. In treatment communities, VVVs received some capacity building: they participated in targeted poultry and nutrition training and were provided with a start-up kit of vaccines. (A cohort of female VVVs was also trained.) However, VVVs were widely present and active in the full sample; this is not an innovation introduced by the intervention.

### B. Description of nutrition and gender component

The nutrition and gender curriculums were distinct, but their implementation was fully integrated and delivered by NGOs through local groups and home visits to members. It included a behavior change communication (BCC) curriculum on nutrition and diets provided through women's groups, poultry producer groups, and local community leaders. The BCC activities promoted improved diets at key stages of the lifecycle, including breastfeeding and infant and young child feeding practices, and basic hygiene. The gender component included community-level sensitization on women's economic empowerment and gender equity and strengthening of women's groups. The activities included, for example, training participants from existing women's associations on enterprise development, including village saving and loans and enhancing commercial opportunities. The activities also focused on strengthening women's role in decision-making within households and the community on entrepreneurship, nutritious food production, marketing, consumption, and in child health, feeding and care.

## III. Methods

This randomized controlled trial was conducted within 60 communes (rural and peri-urban) within three targeted regions of Burkina Faso (Boucle du Mouhoun, Centre-Ouest, and Hauts-Bassins). These communes were selected randomly from a group of 79 communes in these regions identified as eligible for scale-up based on the following criteria: they had not previously been exposed to SELEVER pilot programming, they were designated as rural or peri-urban in the national census, and they were accessible by road year-round. Communes were then randomly assigned to the treatment or control arm, and two villages were selected within each commune.[1]

[1] More specifically, a randomization routine that selected 30 treatment communes from the sampling frame, and two villages within each commune, was run with 3,000 replications. Villages that did not have the target population size for the intervention were excluded from the list. The research team then selected the randomization permutation in which the r-squared of a regression of village and commune covariates on assignment to treatment was minimized.

The household-level eligibility criteria then required the identification of households with a woman 15–49 years of age and a child aged 2-4 years living together. A full household census was conducted to identify eligible households, and 15 households were then randomly selected for inclusion, with oversampling of large poultry producers (flock size of more than 20 mature birds). This yields a target baseline sample of 1800 households (60 communes, 120 villages). Ultimately, data was collected in only 119 villages; one village was omitted due to a failure to correctly identify the community in the field.

Surveys were administered at baseline (March—June 2017) and endline (March—August 2020).

The surveys were wide-ranging and administered to both women (the woman who was most knowledgeable about poultry production) and men (the man who was most knowledgeable about poultry production, usually the head of household). The surveys collected data on household economic status and engagement in poultry production, participation in SELEVER programming, men's and women's knowledge and behaviors around nutrition and hygiene, women's subjective well-being (mental health), diets for the index women and child, and empowerment. Anthropometric measurement of young children was also conducted.

Attrition at the endline survey was minimal: 93% of households surveyed at baseline were surveyed again at endline. The primary trial papers also explore bias due to attrition and conclude that it is minimal (Leight, Awonon, Pedehombga, Ganaba, & Gelli, 2021).

Additional surveys were conducted in the lean season (September—October 2017 and September—October 2019) with a smaller subsample of households collected for further longitudinal data collection. This paper will not use the lean season data extensively, but some analysis will draw on variables collected in these supplementary surveys.

### A. Primary outcome variables and variable construction

We concentrate on three primary outcomes: the number of mature birds, women's poultry revenue, and women's poultry profits. Data on each of these outcomes is drawn from the individual interviews with the man and women in each household who was most knowledgeable about poultry activities in the households. Each individual reported the number of poultry owned on the day of the survey by the type of bird (sex and maturity) and breed. Respondents also responded to detailed questions on poultry inputs and sales over the past six months, from which the value of revenue and profits were derived.

In the same surveys where women were asked about their poultry flock, revenues, and profits, they were also asked about their participation in different aspects of the SELEVER program during the past twelve months. With regard to the poultry production and marketing component, women were asked (i) if they were in a poultry-related group, (ii) the number of poultry sessions they attended, (iii) whether they participated in a group training related to poultry business and marketing activities, (iv) and the number of times they used VVV services in the past 12 months. With regard to the nutrition and gender component, women were asked (i) if they belonged to a group where they learned about nutrition, (ii) how many nutrition sessions they had attended in the past 12 months, (iii) whether they ever received a home visit to discuss nutrition related topics, (iv) if they belonged to a group where they discussed women's roles in the household and community, (v) if they ever attended a training related to women's roles in the household and community, (vi) how many gender sessions they had attended in the past 12 months, (vii) ever received home visits to discuss women's role in the household and community

We first developed measurement models for program participation as latent variables[2] using exploratory factor analysis and confirmatory factor analysis (Kline, n.d.). The analysis suggested the adoption of three separate factors for (i) poultry program participation, (ii) VVV home visits (single observed variable), and (iii) nutrition and gender program participation. Importantly, these factors are consistent with the hypothesized program impact pathways and program delivery. The poultry production and marketing component was implemented by one set of NGOs, and VVVs operate independently throughout the region, although uptake of their services was encouraged by the intervention. On the other hand, the nutrition and gender components were completely integrated with one another, and the related home visits were completed by the implementing NGOs and targeted those who participated in group activities. Further analysis of the measurement model structures and modification indices suggested the model fit would be improved if the model allowed for correlated error terms between similar items for nutrition and gender. In the final measurement model, all items loaded well (>0.35), and the overall model fit was adequate (RMSEA=.075; CFI=.955, and TLI= 0.915)[3].

### B. Empirical strategy

To better understand the role of different program components in achieving program attributable impact, we draw on causal mediation methods using a SEM framework. This approach allows us to determine the extent to which each program component is a plausible pathway between the treatment and the outcome. Given that there is limited work using causal mediation to understand potential pathways in the context of RCTs and that even less of this work is focused specifically on complex multisectoral interventions, we first offer a brief review of our approach. Causal mediation aims to consider whether a hypothesized mediator (M) can account for the causal relationship that X has on Y. Earlier approaches, such as those described by Baron and Kenny (1986), require that: (i) X predict Y, (ii) that X predict M, (iii) that M by correlated with Y after controlling for X, and (iv) that the correlation between X and Y be reduced (partial mediation) or eliminated (full mediation). Using these methods in the context of an RCT can strengthen the evidence that X causes Y and, depending on the data collection methods being used, establish temporal ordering, such that M precedes Y (Baron & Kenny, 1986).

Alternative approaches to causal mediation analysis, such as the counterfactual or potential outcomes framework (Imai et al., 2010, 2011), may also be useful methods for evaluating similar research questions. There are clear advantages, however, of using SEM in this particular case, because we are able to use confirmatory factor analysis models to construct latent variables to measure exposure to different program components. Additionally, our specific approach is not limited by many of the common critiques of SEM for causal mediation, because it does not violate key assumptions. The use of this approach relies on several assumptions for the identification of indirect and direct effects (VanderWeele, 2012). Our treatment variable is randomly assigned, meaning we do not violate the assumptions of having no unmeasured confounders of the X-Y relation or the X-M relation (Valente et al., 2020) Additionally, by controlling for baseline covariates and including all program participation components, we greatly reduce concerns about violating the assumptions of no unmeasured

[2] Latent variables are not directly observed but are underlying constructs that can be measured by modeling observed variables.

[3] Model fit was assessed using the following criteria: RMSEA (range 0–1; cut-off values < 0.05 for a good fit and < 0.08 for an adequate fit) CFI, TLI (for both (range 0–1), good fit> 0.95, or > 0.90 adequate fit.

confounders of the M-Y relation conditional on treatment and pretreatment covariates. Moreover, the reference period for program participation establishes a clear temporal ordering such that the measurements of the mediators precede the measurements of the outcomes.

### C. Primary models

For each outcome of interest (mature birds, revenue, and profits), we base the model on the analysis of covariance (ANCOVA) model specified for estimating impact in the published trial protocol. Specifically, the total treatment effect in these models parallels the treatment effects reported in the primary papers reporting trial impacts (Leight, Awonon, Pedehombga, Ganaba, & Gelli, 2021).[4] The model predicts the endline value of the outcome of interest using the randomly assigned treatment variable and the baseline (pre-intervention) control variables for the outcome of interest, household size, and age of the household head. We then added the different elements of program participation (poultry participation, VVV use, and nutrition-gender participation) as potential mediators. For poultry and nutrition-gender participation, the full measurement model described earlier was added. We first fit models with each potential measurement model separately (not shown). We then fit a model that simultaneously includes all 3 program participation components for which we allow covariances between each pair of mediators to covary. All models were fit in R 4.1.1 using the lavaan package (Version 0.6) (Rosseel, 2012). We used full information maximum likelihood to be able to include all observations, even those that had missing values on some variables. We evaluated model fit based on the root mean square error of approximation (RMSEA) ((range 0–1), < 0.05 for a good fit and < 0.08 for an adequate fit), comparative fit index (CFI), and the Tucker-Lewis index (TLI) (both range 0–1, > 0.95 for a good fit, and > 0.90 for an adequate fit. In all cases we report standardized results.

### D. Calculating direct and indirect effects

We assessed mediation by calculating the indirect effects (i.e., share of the total treatment effect attributable to the mediator) of each potential mediator (poultry participation, VVV use, and nutrition-gender participation), as well as their joint value. We also estimate the direct effects (i.e., share of the total effect remaining after all specified indirect effects are accounted for). We use the terms indirect and direct effects inline with their standard use in the mediation literature. We recognize, however, that this terminology is counterintuitive in that the indirect effects in mediation terminology are in fact the effects of the program directly through its primary program pathways.

Each potential mediator was regressed on the treatment variable to estimate each a path. Then, the dependent variable was regressed on the mediators to estimate the b-paths and the c' path. For each hypothesized mediator the indirect effect was calculated from the values of the respective a and b-paths using bootstrapping (1000 repetitions) to account for concerns that the product a*b is often not normally distributed (Preacher & Hayes, 2008). Bootstrapping procedures often produces asymmetric confidence intervals and statistical significance is determined based on whether confidence intervals overlap zero: We interpret 95% confidence intervals as significant, and 90% confidence intervals as marginally significant. Given our interest in the joint contribution of program participation, in addition to the individual components, we focus on the model that simultaneously includes all program participation components. Therefore, we allow the covariances between each pair of program

[4] There are some very small differences in the estimated coefficients reflecting the use of different sets of baseline covariates.

components to be freely estimated. The total indirect effect of the program components is the sum of the indirect effects of each component in the full model. The remaining direct effect is c', or aspects of the treatment effect that we somehow are not accounting for (in the discussion section we consider in greater detail what these could potentially be). The total effect is the sum of all indirect and remaining direct effects, and this value should be equal to the value of the c path—relationship between the treatment and outcome variable without the mediators in the model.

## IV. Results

### A. Descriptive characteristics

Table 1 presents some overall descriptive statistics for the sample, focusing first on simple demographic characteristics of households as well as their production characteristics (for poultry owned by the household and poultry owned by women specifically), and second for exposure to SELEVER programming. Variables of interest are reported in the endline survey for households in the control arm in Columns (2) through (4) and in the treatment arm in Columns (5) through (7).

We can characterize the households in the sample using baseline data. Households are large on average (including nine members) and characterized by a low level of education (almost all heads of households are men, but only 7% have received primary education). The average household owns 22 mature birds as of the survey date, and reports around $50 in revenue and $35 in profits over the preceding six months. Poultry husbandry reported by women is clearly much smaller in scale, however: women report ownership of only two to three mature birds, with revenue of around $3.50 and profits of around $3 over the preceding six months.

For exposure to SELEVER programming, we can see that about a quarter of women in treatment communities reported engagement in any form of poultry-related activity. About 10% reported that they were members of poultry producers' group or attended business training. Around 20% reported any engagement in nutrition or gender programming: only 3-4% report membership of a discussion group around nutrition or gender topics, and roughly the same proportion report home visits.

### B. Summary of primary trial findings

The primary trial findings analyzed the effects of the SELEVER intervention on a set of pre-specified outcomes linked to poultry, gender, and nutrition. In light of the focus of this paper, we highlight primarily the trial outcomes for poultry as reported in (Leight, Awonon, Pedehombga, Ganaba, Martinez, et al., 2021), but will also allude to the effects on other domains. In general, there is only weak evidence of a significant and positive effect of SELEVER on the primary outcomes linked to poultry (number of mature birds, revenue, and profits at the household level) as well as secondary outcomes (poultry knowledge and profits). Households in communities exposed to SELEVER do show evidence of more knowledge around poultry production and increased use of recommended practices, including concentrate feeding, deworming, and vaccinations; these effects are particularly pronounced in the lean season survey (Leight, Awonon, Pedehombga, Ganaba, Martinez, et al., 2021). However, there is only weak evidence of an increase in flock size, and no evidence of an increase in revenue or profits at the household level in the endline survey (Leight, Awonon, Pedehombga, Ganaba, & Gelli, 2021).

There is, however, a positive and significant effect on production of poultry owned by women. Women report increases in the number of birds owned, revenue and profits that are statistically significant (CITE). For the number of mature birds, we observe an increase of around one bird for households in communities exposed to SELEVER, statistically significant at the one percent level; and for both revenue and profits, we observe an increase of between $1 and $2, both statistically significant at the five percent level. Given that women's flocks at baseline were quite low on average (two mature birds, corresponding to average profits of $5 over the previous six months), the effects are not large in absolute magnitude, but they are large relative to the mean levels observed in the control arm (30-50%). The effects for poultry production reported for poultry owned by men and women jointly are, however, generally negative, hence the null effects observed at the household level. Moving beyond poultry outcomes, we generally observe null effects on dietary outcomes for women and children (micronutrient intake, an individual dietary diversity score, and minimum acceptable diet). We similarly observe null effects on women's empowerment as measured by the pro-WEAI index.

In this analysis, we focus on the primary trial outcomes for poultry (number of mature birds, revenue, and poultry), but narrow our focus to the reported outcomes for poultry owned by women. Given the program impact pathways described previously in more detail above, we hypothesize that the mediating effect of program exposure should be largest for the number of mature birds, an outcome that may be directly responsive to enhanced use of poultry inputs (poultry feed, deworming and vaccination) as promoted through SELEVER. Revenue and profits from poultry sales are outcomes that are less proximal to the enhanced use of inputs, and thus the mediating effect on poultry pathways may be reduced.

### C. SEM estimation results

We first analyze the model predicting the change in the number of mature birds owned by women and testing the simultaneous indirect effects of exposure to poultry programming, gender, and nutrition programming, and VVV services, presented in Columns (1) to (3) of Table 2. The model fits well according to the CFI (.95), TLI (.92) and RMSEA (.05). The a-paths, analyzing the effect of SELEVER on each domain of exposure, suggest that random assignment to SELEVER is associated with a significant and large increase in exposure to the poultry intervention ($\beta$ = 0.642, 95% CI: 0.510—0.763), the nutrition intervention ($\beta$ = 0.300, 95% CI: 0.168—0.409), and VVV services ($\beta$ = 0.255, 95% CI: 0.129—0.395). The magnitude of the effect is largest for poultry exposure, where the coefficient is more than double the magnitude of the coefficient observed for nutrition and VV exposure. The b-paths describe the associations between each mediator (form of program exposure) and women's ownership of mature birds and suggest that only VVV exposure is significantly associated with enhanced flock size ($\beta$ = 1.066, 95% CI: 0.302—1.935). The association between poultry intervention exposure and number of mature birds is in the expected direction but not statistically significant ($\beta$ = 0.438, 95% CI: -0.873—1.802), while the association between nutrition intervention exposure and number of mature birds is negative ($\beta$ = -0.227, 95% CI: -1.479—1.163). When we decompose the indirect effects via program exposure, we find that only the indirect effect via VVV exposure is positive and statistically significant ($\beta$ = 0.272, 95% CI: 0.059—0.590), though the effect estimated via poultry exposure is of comparable magnitude ($\beta$ =0.281, 95% CI: -0.542—1.153), though statistically insignificant. The combined indirect effect was also significant, and the ratio of the indirect effect to total effects suggests that 43% of the total effect is mediated by these indirect channels. Figure 1 captures these results in graphical form, showing the relationships between each variable of interest and the estimated coefficients on the a, b and c' paths.

This enables us to visually summarize the connections between the explanatory variables, the mediating variables, and the outcome variables.

Columns (4) to (6) of Table 2 present the results for revenue from poultry owned by women. Again, the model fits well according to the CFI, TLI and RMSEA, and the a-paths capturing the associations between SELEVER and program exposure are nearly identical to those previously described for the number of poultry owned by women. The b-paths again reveal that only VVV exposure is significantly associated with higher revenue from poultry owned by women (β = 1.768, 95% CI: 0.624—3.070). (This association is, moreover, larger in magnitude vis-à-vis the parallel association estimated for the number of mature birds.) The association between poultry exposure and revenue is positive, but small in magnitude and insignificant (β = 0.322, 95% CI: -1.366—2.014), and the association between nutrition exposure and revenue is again negative (β =-0.171, 95% CI: -1.770—1.228). Decomposing the indirect effects via program exposure, again only the indirect effect of VVV exposure is statistically significant (β = 0.451, 95% CI: 0.114—0.946), while the other two indirect effects are insignificant. The total indirect effect is also no longer statistically significant, and it accounts for only 33% of the total effect.

Finally, Columns (7) to (9) of Table 2 present the results for profits from poultry owned by women. Again, the model fits well according to the CFI, TLI and RMSEA, and the a-paths capturing the associations between SELEVER and program exposure are nearly identical to those previously described for the number of poultry owned by women. Here, when we examine the b-paths we observe that no dimension of program exposure is significantly associated with higher profits. The coefficients on VVV exposure (β =0.890, 95% CI: -0.027—1.938) and poultry exposure (β = 0.441, 95% CI: -0.820—1.991) are positive but statistically insignificant, and the coefficient on nutrition / gender exposure is again negative (β = -0.257, 95% CI: -1.497—0.756). Decomposing the indirect effects, we observe that all three indirect effects are small in magnitude and statistically insignificant, as is the overall indirect effect (β = 0.434, 95% CI: -0.127—1.197). The indirect effect via program exposure thus accounts for only percentage points of the overall percentage point effect. Figures 2 and 3 present the estimated models for revenue and profits from women's poultry participation graphically.

Table 3 presents parallel results estimated using data from both the endline and lean season survey rounds. In general, we observe a similar pattern in which between 30% and 50% of the total effect is mediated by the program participation variables. VVV exposure is again the only dimension that is consistently positively associated with the outcome variables of interest, and it is clear that this is VVV exposure in the endline survey.

## V. Discussion and Conclusion

Our paper contributes to the limited literature that incorporates insights from causal mediation literature in understanding the effect of complex nutrition and agricultural interventions. The findings of this analysis are consistent with several interpretations. One is that self-reported participation is not a fully accurate proxy for household's real engagement with the intervention; or, alternatively, households who currently do not report participation had previously participated, and there were some lagged positive effects of their engagement. This measurement error is particularly relevant for an information only intervention where program participation is not always easily or accurately labeled by participants (in contrast to, for example, food or cash transfers).

A second possibility is that there are substantial indirect effects or spillovers of SELEVER in participating communities, via informational spillovers or other local-level shifts, and because of these effects, the share of the overall intervention impact mediated by specific dimensions of program participation is not high. However, the primary analysis of the trial data did not suggest that large spillovers were present (Leight, Awonon, Pedehombga, Ganaba, & Gelli, 2021).

Another important implication of the study findings is that there may be trade-offs between participation in the different program components, as reflected by the negative coefficients found on the gender and nutrition components in the full SEM. We can speculate that this may be due to the specific implementation of SELEVER, involving little actual integration of program activities across sectors as reported in the process evaluation, that will require further investigation.

In general, the use of causal mediation analysis in analyzing RCT data remains infrequent, and this is thus a meaningful contribution made by this paper. Previous evidence also from Burkina Faso analyzed whether women's empowerment was a pathway to improving child nutrition outcomes in a nutrition-sensitive agriculture program (Heckert et al., 2019). Another recent paper evaluated the role of women's ownership of assets in mediating the positive effects of a multifaceted program targeting poverty reduction (a "graduation model" program) also implemented in Burkina, and found that asset ownership largely was not a meaningful mediator (Karimli et al., 2021). Analysis of a prenatal supplement analyzed in a large-scale trial in Burkina Faso also examined mediating factors in predicting infant nutritional status (Roberfroid et al., 2012).

In addition, the literature around large-scale nutrition interventions (and agricultural-related interventions) has increasingly highlighted the importance of adopting the techniques and frameworks of implementation science to understand the effects of large-scale, complex nutrition interventions (Arabi et al., 2019). A recent review paper highlighted the multiple pathways through which nutrition-sensitive agriculture interventions can shift nutrition outcomes and the importance of designing evaluations that can assess multiple pathways (Sharma et al., 2021). Using causal mediation to unpack the effects of exposure to diverse program elements on outcomes of interest is a useful contribution to understanding the relationship between implementation of complex interventions such as SELEVER and program outcomes. In conclusion, the evidence presented in this paper suggests that for complex multisectoral interventions, direct program exposure may mediate only part of the overall estimated program effect. Indirect effects or local spillover effects may also be important and understanding the channels for these indirect effects is an important direction for further analysis.

**References**


Arabi, M., Rana, Y., Alayón, S., & Danton, H. (2019). Applying an Implementation Science Framework to Define and Assess Effectiveness in a Flagship Multi Country, Multi Sectoral Nutrition Project: The USAID Advancing Nutrition (P10-127-19). *Current Developments in Nutrition*, *3*(Supplement_1). https://doi.org/10.1093/cdn/nzz034.P10-127-19

Baron, R. M., & Kenny, D. A. (1986). The moderator-mediator variable distinction in social psychological research: conceptual, strategic, and statistical considerations. *Journal of Personality and Social Psychology*, *51*(6), 1173–1182. https://doi.org/10.1037//0022-3514.51.6.1173

Bliznashka, L., Arsenault, J. E., Becquey, E., Ruel, M. T., & Olney, D. K. (2020). Using structural equation modelling to understand the contributors to anaemia among young Burkinabe children. *Maternal & Child Nutrition*, *16*(1), e12881. https://doi.org/https://doi.org/10.1111/mcn.12881

Gelli, A., Becquey, E., Ganaba, R., Headey, D., Hidrobo, M., Huybregts, L., Verhoef, H., Kenfack, R., Zongouri, S., & Guedenet, H. (2017). Improving diets and nutrition through an integrated poultry value chain and nutrition intervention (SELEVER) in Burkina Faso: study protocol for a randomized trial. *Trials*, *18*(1), 412. https://doi.org/10.1186/s13063-017-2156-4

Gillespie, S., & van den Bold, M. (2017). Agriculture, Food Systems, and Nutrition: Meeting the Challenge. *Global Challenges*, *1*(3), 1600002. https://doi.org/https://doi.org/10.1002/gch2.201600002

Heckert, J., Olney, D. K., & Ruel, M. T. (2019). Is women's empowerment a pathway to improving child nutrition outcomes in a nutrition-sensitive agriculture program?: Evidence from a randomized controlled trial in Burkina Faso. *Social Science & Medicine*, *233*, 93–102. https://doi.org/https://doi.org/10.1016/j.socscimed.2019.05.016

Imai, K., Jo, B., & Stuart, E. A. (2011). Commentary: Using Potential Outcomes to Understand Causal Mediation Analysis. *Multivariate Behavioral Research*, *46*(5), 861–873. https://doi.org/10.1080/00273171.2011.606743

Imai, K., Keele, L., & Tingley, D. (2010). A general approach to causal mediation analysis. In *Psychological Methods* (Vol. 15, Issue 4, pp. 309–334). American Psychological Association. https://doi.org/10.1037/a0020761

Karimli, L., Lecoutere, E., Wells, C. R., & Ismayilova, L. (2021). More Assets, More Decision-Making Power? Mediation Model in a Cluster-Randomized Controlled Trial Evaluating the Effect of the Graduation Program on Women's Empowerment in Burkina Faso. *World Development*, *137*. http://search.ebscohost.com/login.aspx?direct=true&db=eoh&AN=1858902&site=ehost-live

Kline, R. B. (n.d.). *Principles and practice of structural equation modeling*. Third edition. New York : Guilford Press, [2011] ©2011.

Leight, J., Awonon, J., Pedehombga, A., Ganaba, R., & Gelli, A. (2021). How Light is too Light Touch: The Effect of a Short Training-based Intervention on Household Poultry Production in Burkina Faso. *Journal of Development Economics*.

Leight, J., Awonon, J., Pedehombga, A., Ganaba, R., Martinez, E., Heckert, J., & Gelli, A. (2021). The impact of an integrated value chain intervention on household poultry production in Burkina Faso: evidence from a randomized controlled trial. *Journal of Development Effectiveness*, 1–17. https://doi.org/10.1080/19439342.2021.1968932

Masset, E., Haddad, L., Cornelius, A., & Isaza-Castro, J. (2012). Effectiveness of agricultural interventions that aim to improve nutritional status of children: systematic review. *BMJ*, *344*, d8222. https://doi.org/10.1136/bmj.d8222

Mayne, J., & Johnson, N. (2015). Using theories of change in the CGIAR Research Program on Agriculture for Nutrition and Health. *Evaluation*, *21*(4), 407–428. https://doi.org/10.1177/1356389015605198

Preacher, K. J., & Hayes, A. F. (2008). Asymptotic and resampling strategies for assessing and comparing indirect effects in multiple mediator models. *Behavior Research Methods*, *40*(3), 879–891. https://doi.org/10.3758/BRM.40.3.879

Roberfroid, D., Huybregts, L., Lanou, H., Ouedraogo, L., Henry, M.-C., Meda, N., Kolsteren, P., & group, for the M. study. (2012). Impact of prenatal multiple micronutrients on survival and growth during infancy: a randomized controlled trial. *The American Journal of Clinical Nutrition*, *95*(4), 916–924. https://doi.org/10.3945/ajcn.111.029033

Rosseel, Y. (2012). lavaan: An R Package for Structural Equation Modeling. *Journal of Statistical Software*, *48*(2 SE-Articles), 1–36. https://doi.org/10.18637/jss.v048.i02

Ruel, M. T., & Alderman, H. (2013). Nutrition-sensitive interventions and programmes: how can they help to accelerate progress in improving maternal and child nutrition? *The Lancet*, *382*(9891), 536–551. https://doi.org/https://doi.org/10.1016/S0140-6736(13)60843-0

Sharma, I. K., Di Prima, S., Essink, D., & Broerse, J. E. W. (2021). Nutrition-Sensitive Agriculture: A Systematic Review of Impact Pathways to Nutrition Outcomes. *Advances in Nutrition*, *12*(1), 251–275. https://doi.org/10.1093/advances/nmaa103

Valente, M. J., Rijnhart, J. J. M., Smyth, H. L., Muniz, F. B., & MacKinnon, D. P. (2020). Causal Mediation Programs in R, Mplus, SAS, SPSS, and Stata. *Structural Equation Modeling : A Multidisciplinary Journal*, *27*(6), 975–984. https://doi.org/10.1080/10705511.2020.1777133

VanderWeele, T. J. (2012). Invited Commentary: Structural Equation Models and Epidemiologic Analysis. *American Journal of Epidemiology*, *176*(7), 608–612. https://doi.org/10.1093/aje/kws213

| | Control | | | Treatment | | |
|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) |
| | Mean | St. dev. | Obs. | Mean | St. dev. | Obs. |
| Age head of household | 43.53 | 12.77 | 841 | 44.29 | 13.03 | 828 |
| Household size | 8.79 | 4.80 | 841 | 8.87 | 4.52 | 828 |
| Polygamous household? | 0.47 | 0.50 | 841 | 0.48 | 0.50 | 828 |
| Household head completed primary education | 0.08 | 0.28 | 841 | 0.06 | 0.24 | 828 |
| Household: number of mature birds | 22.54 | 20.86 | 842 | 24.29 | 22.46 | 831 |
| Household: poultry revenue | 48.17 | 66.39 | 842 | 47.51 | 63.74 | 831 |
| Household: poultry profit | 36.36 | 66.72 | 842 | 34.23 | 60.94 | 831 |
| Women: number of mature birds | 2.24 | 6.26 | 842 | 3.42 | 9.01 | 831 |
| Women: poultry revenue | 3.46 | 13.40 | 842 | 5.40 | 17.69 | 831 |
| Women: profit from poultry | 2.26 | 13.77 | 842 | 4.07 | 15.65 | 831 |
| | | | | | | |
| Member of poultry group | 0.01 | 0.09 | 802 | 0.09 | 0.29 | 787 |
| Number of poultry training sessions | 0.04 | 0.24 | 802 | 0.26 | 0.80 | 786 |
| Attended business training | 0.04 | 0.19 | 802 | 0.10 | 0.30 | 787 |
| Any SELEVER poultry programming | 0.06 | 0.25 | 802 | 0.24 | 0.43 | 787 |
| Member of nutrition group | 0.02 | 0.14 | 802 | 0.04 | 0.19 | 787 |
| Number of nutrition sessions (conditional on attendance) | 1.85 | 1.04 | 72 | 1.92 | 1.89 | 122 |
| Nutrition home visit | 0.03 | 0.18 | 802 | 0.04 | 0.20 | 787 |
| Attended gender session | 0.02 | 0.14 | 802 | 0.08 | 0.27 | 787 |
| Number of gender sessions (conditional on attendance) | 2.67 | 2.44 | 15 | 1.92 | 2.17 | 59 |
| Member of gender discussion group | 0.01 | 0.10 | 802 | 0.03 | 0.16 | 787 |
| Gender home visit | 0.02 | 0.13 | 802 | 0.03 | 0.16 | 787 |
| Any SELEVER nutrition / gender programming | 0.11 | 0.31 | 802 | 0.20 | 0.40 | 787 |
| Number of nutrition services past year | 0.94 | 1.12 | 765 | 1.20 | 1.36 | 747 |

Table 1: Summary statistics on household demographics and program exposure

| | Number of mature birds | | | Revenue | | | Profits | | |
|---|---|---|---|---|---|---|---|---|---|
| | Beta | LCI 95% | UCI 95% | Beta | LCI 95% | UCI 95% | Beta | LCI 95% | UCI 95% |
| Poultry exposure | | | | | | | | | |
| Poultry producers' group membership | 0.097 | 0.070 | 0.126 | 0.097 | 0.072 | 0.123 | 0.096 | 0.069 | 0.123 |
| Number of poultry group sessions attended | 0.377 | 0.275 | 0.477 | 0.378 | 0.278 | 0.474 | 0.377 | 0.270 | 0.472 |
| Attended business training | 0.105 | 0.076 | 0.130 | 0.105 | 0.078 | 0.132 | 0.105 | 0.077 | 0.133 |
| SELEVER | 0.642 | 0.510 | 0.763 | 0.641 | 0.527 | 0.784 | 0.643 | 0.510 | 0.777 |
| Nutrition / gender exposure | | | | | | | | | |
| Nutrition group membership | 0.061 | 0.035 | 0.089 | 0.061 | 0.035 | 0.087 | 0.061 | 0.035 | 0.087 |
| How many nutrition sessions attended | 0.436 | 0.315 | 0.546 | 0.436 | 0.319 | 0.549 | 0.436 | 0.324 | 0.544 |
| Received nutrition home visit | 0.078 | 0.049 | 0.107 | 0.078 | 0.047 | 0.109 | 0.078 | 0.048 | 0.107 |
| Attended discussion session around gender roles | 0.160 | 0.127 | 0.188 | 0.160 | 0.127 | 0.187 | 0.160 | 0.127 | 0.187 |
| How many gender sessions attended | 0.312 | 0.217 | 0.412 | 0.312 | 0.217 | 0.404 | 0.312 | 0.217 | 0.408 |
| Membership of gender discussion group | 0.085 | 0.055 | 0.115 | 0.085 | 0.056 | 0.115 | 0.085 | 0.056 | 0.115 |
| Received gender home visit | 0.069 | 0.041 | 0.099 | 0.069 | 0.039 | 0.100 | 0.069 | 0.038 | 0.100 |
| SELEVER | 0.300 | 0.168 | 0.409 | 0.301 | 0.171 | 0.414 | 0.301 | 0.168 | 0.409 |
| VVV exposure | | | | | | | | | |
| SELEVER | 0.255 | 0.129 | 0.395 | 0.255 | 0.129 | 0.389 | 0.256 | 0.114 | 0.384 |
| Dependent variable | | | | | | | | | |
| SELEVER | 0.652 | -0.144 | 1.437 | 1.208 | -0.584 | 3.014 | 1.326 | -0.344 | 2.906 |
| Poultry exposure | 0.438 | -0.873 | 1.802 | 0.322 | -1.366 | 2.014 | 0.441 | -0.820 | 1.991 |
| Nutrition / gender exposure | -0.227 | -1.479 | 1.163 | -0.171 | -1.770 | 1.228 | -0.257 | -1.497 | 0.756 |
| VVV exposure | 1.066 | 0.302 | 1.935 | 1.768 | 0.624 | 3.070 | 0.890 | -0.027 | 1.938 |

| | Number of mature birds | | | Revenue | | | Profits | | |
|---|---|---|---|---|---|---|---|---|---|
| | Beta | LCI 95% | UCI 95% | Beta | LCI 95% | UCI 95% | Beta | LCI 95% | UCI 95% |
| Fit statistics | | | | | | | | | |
| CFI | 0.955 | | | | | | | | |
| TLI | 0.915 | | | | | | | | |
| RMSEA | 0.075 | | | | | | | | |
| Direct, indirect, and total effects calculated from the path coefficients in the structural equation models | | | | | | | | | |
| Direct effect of T1 | 0.652 | -0.144 | 1.437 | 1.208 | -0.584 | 3.014 | 1.326 | -0.344 | 2.906 |
| Indirect effects | | | | | | | | | |
| *Via poultry exposure* | 0.281 | -0.542 | 1.153 | 0.207 | -0.814 | 1.384 | 0.283 | -0.514 | 1.304 |
| *Via nutrition / gender exposure* | -0.068 | -0.483 | 0.318 | -0.051 | -0.583 | 0.357 | -0.077 | -0.468 | 0.244 |
| *Via VVV exposure* | 0.272 | 0.059 | 0.590 | 0.451 | 0.114 | 0.946 | 0.228 | -0.006 | 0.544 |
| Total indirect effect | 0.485 | 0.002 | 1.135 | 0.606 | -0.030 | 1.490 | 0.434 | -0.127 | 1.197 |
| Total effect | 1.137 | 0.406 | 1.921 | 1.814 | 0.829 | 0.442 | 1.760 | 0.291 | 3.131 |
| % total effect mediated by program participation | 0.427 | | | 0.334 | | | | | |

Table 2: Results of structural equation models

| | Number of mature birds | | | Revenue | | | Profits | | |
|---|---|---|---|---|---|---|---|---|---|
| | Beta | LCI 95% | UCI 95% | Beta | LCI 95% | UCI 95% | Beta | LCI 95% | UCI 95% |
| Poultry exposure | | | | | | | | | |
| Poultry producers' group membership | 0.099 | 0.072 | 0.125 | 0.099 | 0.072 | 0.124 | 0.099 | 0.069 | 0.124 |
| Number of poultry group sessions attended | 0.372 | 0.276 | 0.477 | 0.373 | 0.268 | 0.471 | 0.373 | 0.270 | 0.469 |
| Attended business training | 0.105 | 0.076 | 0.131 | 0.104 | 0.076 | 0.131 | 0.104 | 0.077 | 0.130 |
| SELEVER | 0.646 | 0.527 | 0.776 | 0.646 | 0.525 | 0.786 | 0.647 | 0.531 | 0.785 |
| Poultry exposure - lean season | | | | | | | | | |
| Poultry producers' group membership | 0.174 | 0.142 | 0.202 | 0.173 | 0.141 | 0.201 | 0.173 | 0.138 | 0.200 |
| Number of poultry group sessions attended | 0.852 | 0.692 | 1.022 | 0.852 | 0.689 | 1.020 | 0.848 | 0.687 | 1.015 |
| Attended business training | 0.203 | 0.163 | 0.236 | 0.203 | 0.169 | 0.234 | 0.202 | 0.163 | 0.233 |
| SELEVER | 0.788 | 0.664 | 0.912 | 0.791 | 0.658 | 0.923 | 0.794 | 0.678 | 0.924 |
| Nutrition / gender exposure | | | | | | | | | |
| Nutrition group membership | 0.061 | 0.034 | 0.087 | 0.061 | 0.034 | 0.086 | 0.061 | 0.037 | 0.089 |
| How many nutrition sessions attended | 0.433 | 0.322 | 0.542 | 0.434 | 0.323 | 0.542 | 0.434 | 0.316 | 0.535 |
| Received nutrition home visit | 0.077 | 0.048 | 0.106 | 0.077 | 0.049 | 0.108 | 0.077 | 0.047 | 0.108 |
| Attended discussion session around gender roles | 0.161 | 0.128 | 0.191 | 0.161 | 0.131 | 0.189 | 0.161 | 0.127 | 0.189 |
| How many gender sessions attended | 0.311 | 0.214 | 0.411 | 0.311 | 0.226 | 0.415 | 0.311 | 0.220 | 0.405 |
| Membership of gender discussion group | 0.084 | 0.056 | 0.114 | 0.084 | 0.056 | 0.113 | 0.084 | 0.055 | 0.115 |
| Received gender home visit | 0.068 | 0.040 | 0.097 | 0.068 | 0.040 | 0.101 | 0.068 | 0.039 | 0.100 |
| SELEVER | 0.301 | 0.179 | 0.401 | 0.302 | 0.165 | 0.413 | 0.302 | 0.170 | 0.403 |

| | Number of mature birds | | | Revenue | | | Profits | | |
|---|---|---|---|---|---|---|---|---|---|
| | Beta | LCI 95% | UCI 95% | Beta | LCI 95% | UCI 95% | Beta | LCI 95% | UCI 95% |
| Nutrition / gender exposure - lean season | | | | | | | | | |
| Nutrition group membership | 0.178 | 0.139 | 0.213 | 0.178 | 0.139 | 0.214 | 0.178 | 0.137 | 0.212 |
| How many nutrition sessions attended | 0.869 | 0.637 | 1.192 | 0.867 | 0.634 | 1.190 | 0.867 | 0.638 | 1.190 |
| Received nutrition home visit | 0.135 | 0.102 | 0.165 | 0.134 | 0.100 | 0.168 | 0.134 | 0.099 | 0.164 |
| Attended discussion session around gender roles | 0.250 | 0.214 | 0.279 | 0.250 | 0.215 | 0.280 | 0.249 | 0.213 | 0.276 |
| How many gender sessions attended | 0.752 | 0.525 | 1.077 | 0.751 | 0.533 | 1.073 | 0.750 | 0.513 | 1.066 |
| Membership of gender discussion group | 0.168 | 0.130 | 0.200 | 0.168 | 0.130 | 0.202 | 0.167 | 0.130 | 0.201 |
| Received gender home visit | 0.131 | 0.099 | 0.162 | 0.131 | 0.097 | 0.164 | 0.131 | 0.094 | 0.161 |
| SELEVER | 0.434 | 0.306 | 0.544 | 0.438 | 0.300 | 0.557 | 0.438 | 0.309 | 0.555 |
| VVV exposure | | | | | | | | | |
| SELEVER | 0.252 | 0.122 | 0.384 | 0.251 | 0.130 | 0.381 | 0.252 | 0.126 | 0.375 |
| VVV exposure - lean season | | | | | | | | | |
| SELEVER | 0.249 | 0.048 | 0.431 | 0.258 | 0.049 | 0.478 | 0.257 | 0.047 | 0.472 |
| Dependent variable | | | | | | | | | |
| SELEVER | 0.595 | -0.357 | 1.583 | 0.936 | -1.303 | 2.847 | 1.204 | -1.092 | 3.175 |
| Poultry exposure | 0.551 | -1.424 | 2.869 | -0.098 | -3.656 | 4.417 | 0.240 | -2.935 | 3.974 |
| Nutrition / gender exposure | -0.371 | -2.189 | 1.218 | 0.064 | -3.127 | 2.406 | -0.123 | -2.774 | 1.736 |
| VVV exposure | 0.958 | 0.028 | 2.030 | 1.784 | 0.509 | 3.176 | 0.888 | -0.285 | 1.967 |
| Dependent variable - lean season | | | | | | | | | |
| Poultry exposure | -0.139 | -2.521 | 1.939 | 1.299 | -3.849 | 6.596 | 0.777 | -3.865 | 5.849 |
| Nutrition / gender exposure | 0.225 | -1.388 | 2.024 | -1.379 | -4.896 | 2.241 | -1.038 | -4.342 | 1.889 |
| VVV exposure | 0.274 | -0.246 | 0.869 | 0.192 | -0.759 | 1.248 | 0.199 | -0.672 | 1.321 |

| | Number of mature birds | | | Revenue | | | Profits | | |
|---|---|---|---|---|---|---|---|---|---|
| | Beta | LCI 95% | UCI 95% | Beta | LCI 95% | UCI 95% | Beta | LCI 95% | UCI 95% |
| Fit statistics | | | | | | | | | |
| CFI | | | | | | | | | |
| TLI | | | | | | | | | |
| RMSEA | | | | | | | | | |
| Direct, indirect, and total effects calculated from the path coefficients in the structural equation models | | | | | | | | | |
| Direct effect of T1 | 0.595 | -0.357 | 1.583 | 0.936 | -1.303 | 2.847 | 1.204 | -1.092 | 3.175 |
| Indirect effects | | | | | | | | | |
| *Via poultry exposure* | 0.356 | -0.960 | 2.034 | -0.064 | -2.427 | 3.029 | 0.155 | -1.848 | 2.652 |
| *Via poultry exposure - lean season* | -0.109 | -1.983 | 1.524 | 1.028 | -3.306 | 5.389 | 0.617 | -3.095 | 4.666 |
| *Via nutrition / gender exposure* | -0.112 | -0.734 | 0.347 | 0.019 | -0.878 | 0.766 | -0.037 | -0.818 | 0.543 |
| *Via nutrition / gender exposure - lean season* | 0.098 | -0.655 | 0.884 | -0.604 | -2.453 | 0.984 | -0.455 | -1.953 | 0.848 |
| *Via VVV exposure* | 0.241 | 0.004 | 0.613 | 0.449 | 0.097 | 1.008 | 0.224 | -0.060 | 0.550 |
| *Via VVV exposure - lean season* | 0.068 | -0.056 | 0.250 | 0.050 | -0.233 | 0.370 | 0.051 | -0.195 | 0.347 |
| Total indirect effect | 0.542 | -0.077 | 1.127 | 0.877 | -0.467 | 2.404 | 0.556 | -0.693 | 2.180 |
| Total effect | 1.137 | 0.388 | 1.928 | 1.814 | 0.272 | 3.345 | 1.759 | 0.338 | 3.352 |
| % total effect mediated by program participation | 0.477 | | | 0.484 | | | 0.316 | | |

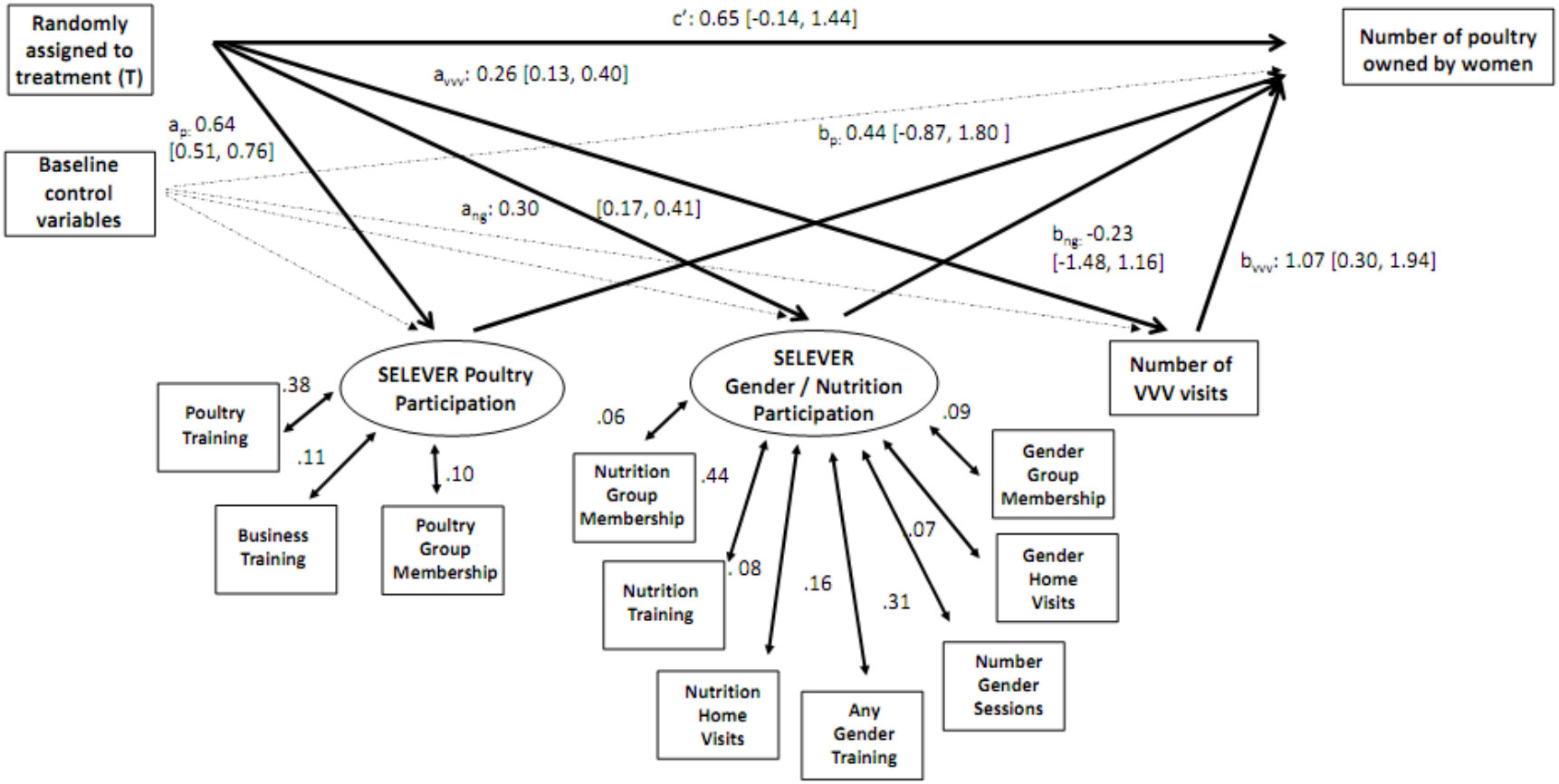
Randomly assigned to treatment (T)
c': 0.65 [-0.14, 1.44]
Number of poultry owned by women
$a_{vvv}$: 0.26 [0.13, 0.40]
$a_p$: 0.64 [0.51, 0.76]
$b_p$: 0.44 [-0.87, 1.80 ]
Baseline control variables
$a_{ng}$: 0.30 [0.17, 0.41]
$b_{ng}$: -0.23 [-1.48, 1.16]
$b_{vvv}$: 1.07 [0.30, 1.94]
SELEVER Poultry Participation
SELEVER Gender / Nutrition Participation
Number of VVV visits
.38
Poultry Training
.11
Business Training
.10
Poultry Group Membership
.06
Nutrition Group Membership
.44
Nutrition Training
. 08
Nutrition Home Visits
.16
Any Gender Training
.31
Number Gender Sessions
.07
Gender Home Visits
.09
Gender Group Membership

Figure 1: SEM model for poultry owned by women

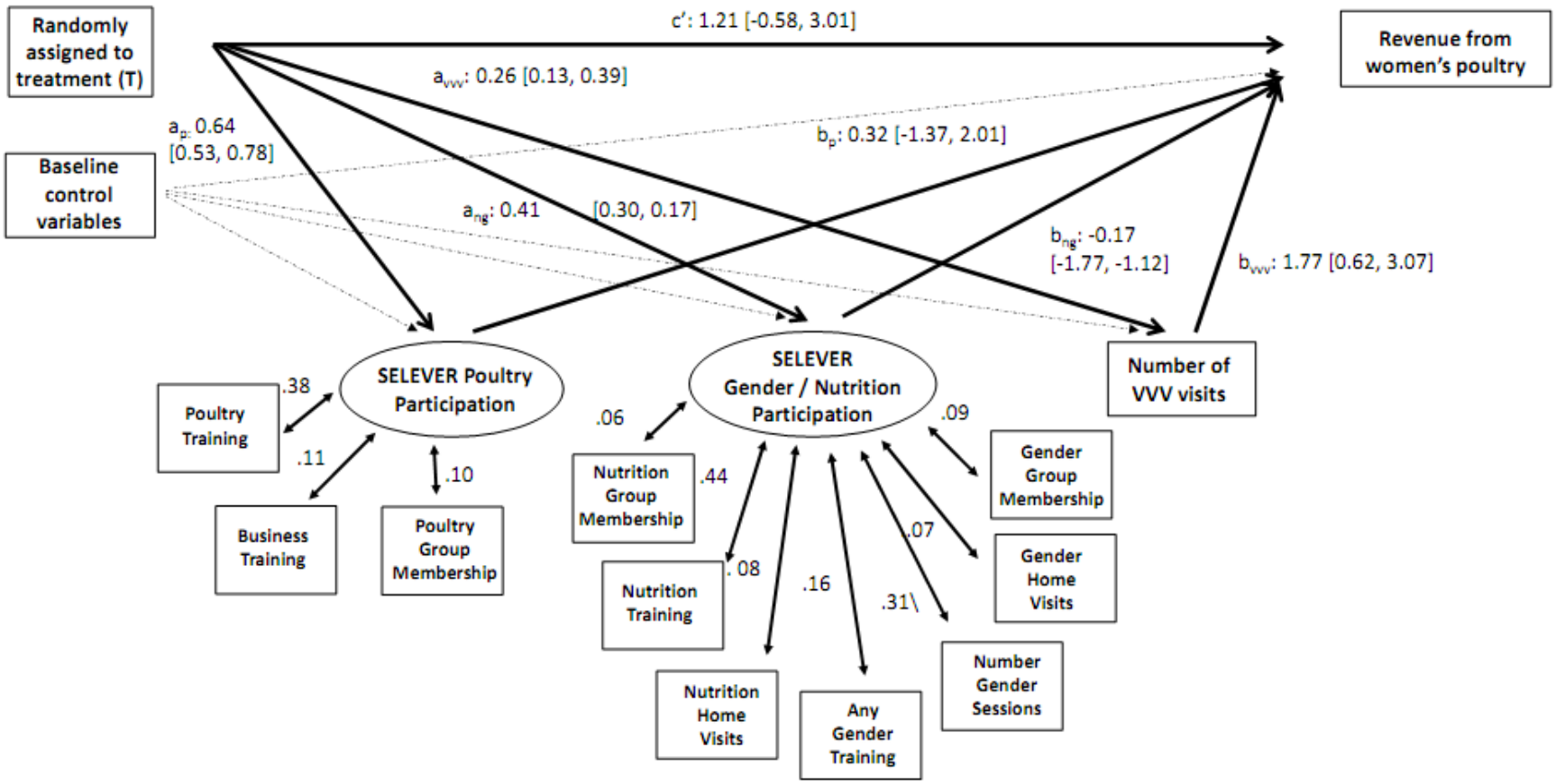


Figure 2: SEM model for women's revenue from poultry production

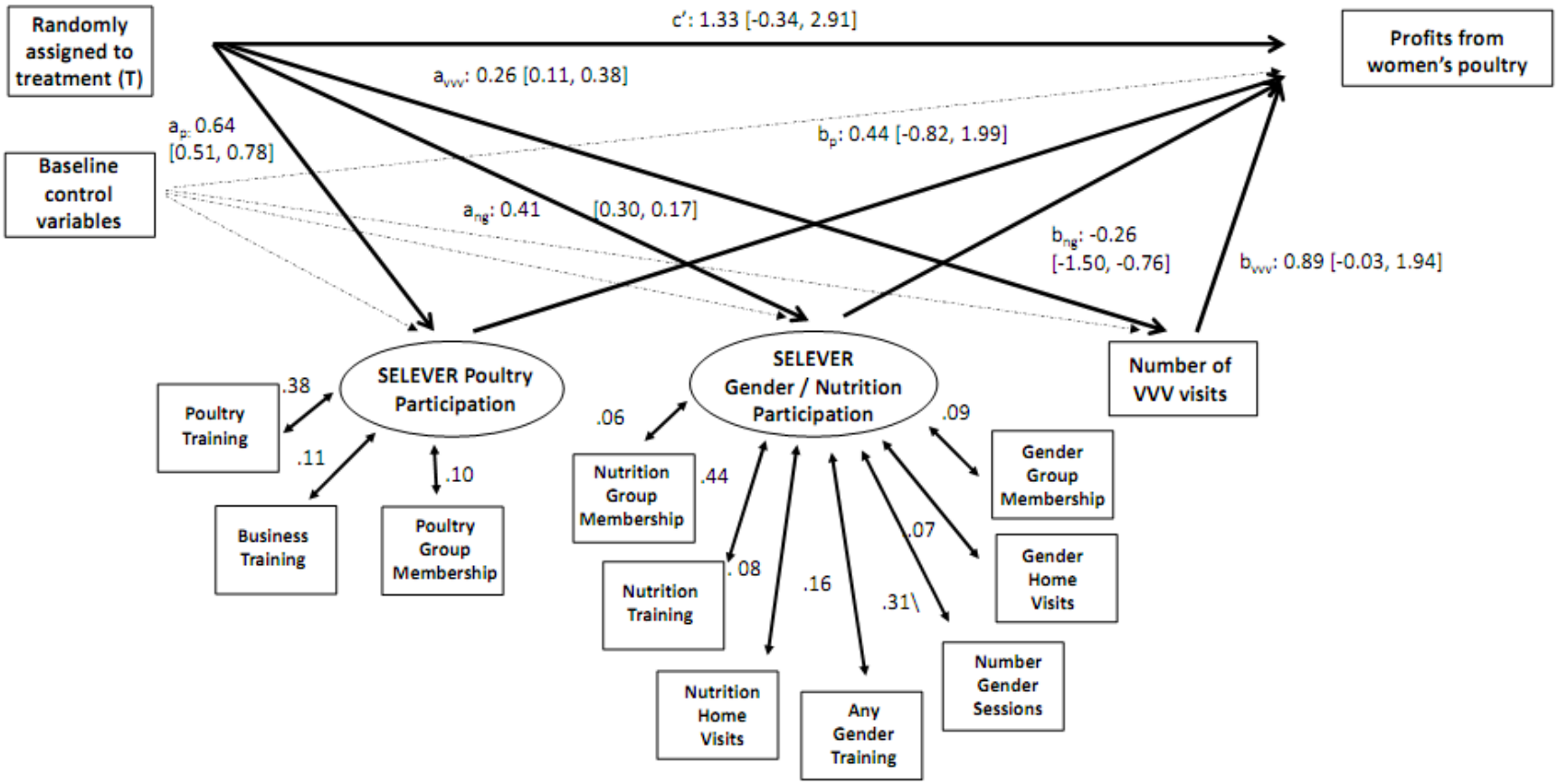


Figure 3: SEM model for women's profits from poultry production

## ALL IFPRI DISCUSSION PAPERS

All discussion papers are available **here**

They can be downloaded free of charge

**INTERNATIONAL FOOD POLICY RESEARCH INSTITUTE**
www.ifpri.org

**IFPRI HEADQUARTERS**

1201 Eye Street, NW
Washington, DC 20005 USA
Tel.: +1-202-862-5600
Fax: +1-202-862-5606
Email: ifpri@cgiar.org