WPS4424

Policy Research Working Paper 4424

Impact Evaluation Series No. 19

# Improving Nutritional Status through Behavioral Change:

## Lessons from Madagascar

*Emanuela Galasso*
*Nithin Umapathi*

The World Bank
Development Research Group
Poverty Team
December 2007

## Abstract

This paper provides evidence of the effects of a large-scale intervention that focuses on the quality of nutritional and child care inputs during the early stages of life. The empirical strategy uses a combination of double-difference and weighting estimators in a longitudinal survey to address the purposive placement of participating communities and estimate the effect of the availability of the program at the community level on nutritional outcomes. The authors find that the program helped 0-5 year old children in the participating communities to bridge the gap in weight for age z-scores and the incidence of underweight. The program also had significant effects in protecting long-term nutritional outcomes (height for age z-scores and incidence of stunting) against an underlying negative trend in the absence of the program. Importantly, the effect of the program exhibits substantial heterogeneity: gains in nutritional outcomes are larger for more educated mothers and for villages with better infrastructure. The program enables the analysis to isolate responsiveness to information provision and disentangle the effect of knowledge in the education effect on nutritional outcomes. The results are suggestive of important complementarities among child care, maternal education, and community infrastructure.


This paper—a product of the Poverty Team, Development Research Group—is part of a larger effort in the department to promote rigorous impact evaluations of anti-poverty programs. Policy Research Working Papers are also posted on the Web at http://econ.worldbank.org. The author may be contacted at egalasso@worldbank.org.

# Improving Nutritional Status through Behavioral Change: Lessons from Madagascar[†]

Emanuela Galasso and Nithin Umapathi

*Development Research Group*
*World Bank*

*University College London, Institute for Fiscal Studies and Centre for Microdata Methods and Practice*

(JEL I12, I18, J13, O15)

Keywords: Community-based program, nutrition, behavioral change, Madagascar

[†] This research has been sponsored by the World Bank Research Grant "Community Nutrition: Evaluation of Impacts in Africa". We thank Claudia Rokx, the project task manager at the onset of the evaluation for her enthusiastic support and Harold Alderman, Anne Bossuyt for very useful discussions, Pedro Carneiro and Imran Rasul for detailed comments on various drafts. We are extremely grateful to the project management unit and to the provincial directors of the Seecaline program in Madagascar for sharing their vast knowledge on the details of the program. We thank Bart Minten for having shared the data on the Commune Census. These are the views of the authors and do not reflect those of the World Bank, its Executive Directors, or the countries they represent. All errors are our own. Correspondence by email to egalasso@worldbank.org or n.umapathi@ucl.ac.uk.

## 1. Introduction

The first years of life mark a critical period for child development[1]. There is a strong consensus that improvements in the nutritional status of infants and young children not only have a direct, short-term impact on their health, but also impact their physical and mental development later in life. In fact, previous studies show that severe malnutrition is an important factor in explaining deficits in cognitive development in early childhood [Grantham-McGregor et al. 1999, Pollitt 1990]. These deficits, in turn, impose persistent costs on both schooling performance and productivity later in life.[2]

There is an equally universally accepted consensus that health inequalities start very early in life: almost all growth retardation occurs in the first two to three years of life, after which the physical and cognitive deficits are very difficult to reverse [Martorell 1995, Shrimpton et al 2005, Berhman et al 2004].

Direct child nutrition interventions are based on the so-called conceptual heuristic model of the production of nutrition adopted by the World Health Organization and UNICEF (1998). In this framework, the immediate causes of malnutrition are based on three interactive pillars: the role of nutrients, through food intake or supplementation; the role of health services and protection from diseases; and the role of child care. The economic literature has focused on the first two pillars of the health production function, namely food and caloric intake or on the socio-economic determinants of child health. The nutrition and public health literature on the other hand has emphasized child care as an independent and important complementary input in the health production function, although few of these studies are able to establish a causal pathway between practices and nutrition. Maternal knowledge of correct practices is not intuitive and does not come automatically. Many mothers do not recognize when children are faltering in growth and suffer from moderate malnutrition. The underlying rationale for a community growth promotion program that targets the third pillar is that malnutrition can be addressed by improving mothers' knowledge about nutrition, hygiene and feeding practices.

In this paper our first objective is to examine, in a causal sense, whether provision of information via community-based programs promotes changes in children's health outcomes within the existing economic resources available to the household. Second, the scale of the program allows us to disaggregate the results according to key socioeconomic characteristics

[1] Referred to as the 'window of opportunity' in the World Bank 'repositioning nutrition' flagship report (2006).

[2] There exists an extensive literature that examines the relationship between cognitive development, schooling attainment, and future earnings. See, among others, Currie and Thomas (1999), Cunha, Heckman, Lochner and Masterov (2006) for the US; Alderman Hoddinott and Kinsey (2006), Glewwe, Jacoby and King (2000), Martorell (1999) for developing countries

of the targeted villages as well as the target population. By looking at the heterogeneity of impact we hope to improve our understanding of the channels through which the program affects outcomes, and to highlight the role of complementary inputs in achieving nutritional gains.

We address these questions in the context of a large scale community based nutrition program: SEECALINE, in Madagascar. The ex-post evaluation design builds on two nationally representative surveys administered before and after the program, longitudinal at the community level. As common in any non-experimental setting, our identification strategy needs to carefully address the non-random selection of communities into the program, due both to purposive targeting of the program to the most malnourished districts of the country, as well as to potential unobserved heterogeneity arising from the decision of the communities to participate in the program [Pitt, Rosenzweig, Gibbons 1993]. The data collection effort was designed to revisit the same communities in a follow-up survey seven years apart, and as such allows us to difference out any selection bias arising from time-invariant characteristics.

Our empirical strategy combines difference-in-difference methods with matching estimation techniques, to measure the effect of program availability at the community level on child nutritional outcomes (*intention-to-treat*). This represents the lower bound on the full effect of the program on the participants.

Our results show that the program helped the participating communities bridge the gap in weight for age z-score by 0.15-0.22 standard deviations and reduced the incidence of underweight by 5.2-7.5 percentage points. The results also indicate that the program had significant effects in terms of longer term nutritional outcomes. The program had a protective effect, preventing Seecaline sites from an increasing trend in stunting. The result is particularly important in light of the fact that SEECALINE communities had a higher incidence of shocks and higher food security constraints. Furthermore, we provide suggestive evidence of the impact of the program on a set of child care practices that document the intervention channels of the program. The program effects were obtained through significant improvements in feeding and hygiene practices such as exclusive breastfeeding, timing of weaning, and child care during diarrhea episodes.

While there have been a few well documented successful applications of such approaches based on case-studies or small-scale programs[3] [Allen and Gillespie, 2001], there is

[3] Notable examples include the Iringa project in Tanzania (Gillespie et al 2003), the Indonesian Nutrition Development Program and the Weaning Program in Indonesia (Favin Griffiths 1999), the ANEP program in the Dominican Republic (USAID 1988), the Nutrition Communication Project in Mali (Ross 1997). There are also

surprisingly little rigorous evidence on how effective these types of interventions are in terms of nutritional outcomes in the context of *large-scale* programs, and whether these positive effects, if observed, are sustained over time.[4] A notable exception comes from the evaluation of an integrated nutrition and early child development project in Uganda [Alderman, 2007]. The evaluation in Uganda shows promising results, with gains for children below one year of age of about 0.22 standard deviations (SD) in weight-for-age z-score as a result of the intervention and important signs of change in health and nutrition practices. The short term time-span of the program, however, precludes the possibility of an assessment of whether these improvements persist in older cohorts. Galasso and Yau (2006) have looked at the same program under study using administrative data collected only for program participants and found that the returns to differential duration exposure of the program are positive.

We focus on two additional results that tie into the current literature on the effect of maternal education and children's health. The important correlation between nutrition knowledge and health outcomes has been established in the economics literature (Glewwe 1999, Christiansen and Alderman 2004, Webb and Block 2004), and knowledge seems to explain most of the correlation between maternal education and nutritional outcomes. But beyond correlations, when does the provision of knowledge to mothers translate into nutritional gains? Furthermore, even if better knowledge leads to improved practices which imply a more efficient use of health inputs [Schultz 1984, Glewwe 1990], they might not be enough to impact health outcomes, since they only represent one of the components of the child health production function[5]. Systematic evidence on the role of such complementary inputs is very scarce [Ruel et al., 1999, Jalan, Ravallion 2003]. The SEECALINE program enables us identify the effect of the information channel of the education effect and also isolate the responsiveness to information. We interpret the differences in the returns to the program across different socio-economic groups in the population and make inferences about the role of these complementarities in light of the literature. We find that although the program explicitly targeted the poorest and more malnourished areas of the country, it is the relatively

---

small studies in the nutrition literature (ex Salehi et al 2004) that point out to the potential of improved practices for improving child growth even under conditions of poverty.

[4] The first large-scale, community-based nutrition programs were implemented in Asia and Central America (Tamil Nadu Integrated Nutrition Project (TINP) and the Bangladesh Integrated Nutrition Project (BINP), and the AIN-C program in Honduras). The programs suffered from weak evaluation design that failed to disentangle the program effect adequately. Comparing differential trends over time in intervention areas versus non-intervention areas might over/under-estimate the true changes due to the intervention if the selection bias due to the purposive targeting is not adequately addressed (Pitt, Rosenzweig, Gibbons 1993).

[5] In the absence of a structural model of the child health production function that encompasses all the relevant inputs, one cannot tease out the underlying relationship between knowledge and adoption of practices, and in turn the link between practices and nutritional outcomes

more educated households and better off villages that were able to translate gains in the behavioral indicators into gains in children's nutritional outcomes. The two sets of results are suggestive of important complementarities in the child health production function between maternal knowledge, maternal education and community resources. The paper proceeds as follows. In section 2 we present the main design features of the program. Section 3 describes the data. The empirical methodology used in the evaluation is presented in section 4. Section 5 describes the findings and finally, section 6 concludes.

## 2. Background: Program and Setting

The program SEECALINE is a large-scale community-based nutrition program in Madagascar that started in 1999 and was gradually scaled up until 2002 to cover more than half of the country's districts. The objective of the program is to improve the nutritional status of children under the age of three and of pregnant and lactating mothers in the targeted project areas. To maximize geographical coverage as well as to provide quality services on a large scale, the program is contracted out to local NGOs for implementation (management, delivery, operations research and supervision) at the local level. The services are delivered locally by a community nutrition worker (*agent communautaire de la nutrition, ACN*), who is usually a woman elected from the targeted community.

Seecaline adopts a preventive approach to combat malnutrition. The program revolves around a monthly growth monitoring and promotion activity as a focal point. The participating communities are mobilized towards becoming aware of the problem of malnutrition and are taught and encouraged to improve hygiene, child care and nutrition practices. At the core of the Seecaline message is raising awareness of the importance of exclusive breastfeeding (at least until 6 months of age), on the timing and composition of the introduction of complementary food, on appropriate feeding practices and child care during illnesses. Some of the messages are not exclusive to the program. For instance, the encouragement to breastfeed or feed more fluids during episodes of diarrhea has been a nationwide program widely publicized by other programs as well as aired through the radio. In this respect, what we are testing is the receptiveness of mothers to a direct delivery of the message by the ACN over and above the general message.

All children under the age of three and the pregnant and lactating women in the targeted communities are eligible to participate in all of the program activities. On a monthly basis, the ACN weighs all the children under the age of three and provides counseling to the mothers regarding the nutritional status of their children indicated by the growth chart. The ACN may also do home visits if the child's growth chart shows no progress or if he/she misses a weighing session. The community nutrition workers are paid and get help from a group of local volunteers (support group)[6] in their activities related to Seecaline.

The ACN carries out a yearly census of all the children under the age of three, registering their names and mobilizing the mothers to participate in the weighing and education sessions. The promotion of behavioral change (besides the direct counseling to mothers) includes nutrition and hygiene education sessions, and cooking demonstrations by the community nutrition worker where she emphasizes the proper weaning practices and prepares recipes that rely on locally available products to promote a healthy and diversified diet.

The program was gradually phased in. Seecaline activities started in 1999 in four provinces and expanded to all six provinces in 2000.[7] The selection of the district was based on a nationally representative anthropometric survey collected in 1997/98, which represents the baseline data for our evaluation. All districts (46 out of 111) that had an average malnutrition rate (moderate underweight) above the national average were selected for the intervention (43%). In addition, ten rural districts affected by droughts and cyclones in the year 2000 were added to the program.[8] The program expansion stopped at the end of 2001/beginning of 2002 to reach about 3,600 project sites.

The program expansion followed a sequential contractual engagement of NGOs across districts. NGOs were selected based on a bidding workshop organized every year around August/September[9]. The selected NGOs were then assigned a number of sites in any given district, based on an estimate of the target population in the districts.

The program in each province was initially advertised to all mayors of the communes included within the district. Mayors would then organize a meeting with all the communities to make them aware of the program and to encourage them to participate. A community had to be eligible to open a project site and geographically accessible for most part of the year (by auto/motorbike, chariot or pirogue). Accessibility in Madagascar is a major constraint for

[6] The support group generally consists of eight members who help the ACN in organizing her weighing session and in other regular activities of the community program. Besides growth monitoring, the program provides other activities. All of the children are given micronutrient supplementation (vitamin A) and de-worming (for children 1-3).

[7] CNII is an extension of an earlier Bank pilot project originally targeted to two provinces (Antananarivo and Toliara).

[8] The total number of sites to be opened in each district was chosen to reach a coverage rate of 50% of all children below three years of age in the intervention areas. The 50% target was to be achieved gradually over time, with 10% coverage per year in the first two years of operation and 15% coverage per year in the third and forth years. Finally six additional urban districts that cover the province capitals were added in 2002, in the aftermath of a political crisis. Emergency sites were opened to alleviate the cost of the crisis on urban populations, and were subsequently made permanent. We exclude these large cities from the analysis because the nature of the intervention as well as the socio-economic environment is substantially different from the rest of the country.

[9] Eligible NGOs had to have had at least one year of experience in the district of intervention.

service delivery, and the phasing in of the program reflected this constraint. The NGO, and more specifically the animator who is in charge of supervising and providing support to the community nutrition worker, needed to be able to reach the sites regularly by motorbike.

Once the community was eligible and decided to participate, an ACN was locally elected and provided an initial intense training by the provincial directors.[10] In the current design of the community program (PNC), a site is planned to have a maximum number of 225 children (below the age of three). Everybody in the community is eligible to participate in the site activities.

## 3. The Data and Descriptive Evidence

A baseline household survey was fielded in the months of April and July of 1997 and 1998 by the National Institute of Statistics (INSTAT-DDSS), in all but three districts of the country.[11] The survey was administered to about 14,000 households.[12]

The objective of the baseline survey was to obtain a sufficiently precise estimate of the incidence of malnutrition at the district level, so as to target the intervention in the districts with an incidence of moderate underweight above the national average. As a consequence, a shorter large scale survey was required, collecting anthropometric information as well as the education of the mother and the occupation of the head of the household. Anthropometric measures were recorded for children 6 to 59 months as well as for all women 15-49 in the sample.

A follow-up, nationally representative anthropometric survey was administered in 2004 in the same season as in the 1997/98 sample.[13] In order to be able to control for both observed and unobserved community level characteristics in the evaluation, the survey was planned to be administered to the same communities (Fokontany) interviewed during the baseline survey, thereby creating a longitudinal panel at the community level. About one-third (154 out of 420) of the communities at baseline were subsequently selected for the program.

[10] Note that we are using communities and program sites interchangeably. A site is identified by its geographical delimitation (of a radius of five kilometers, within the commune boundaries). A site generally comprises 1 to 3 villages. The boundaries were set to minimize the transport (direct and indirect) cost of joining the site activities by mothers as well as to minimize the burden for the community worker.

[11] The district comprising the capital (Antananarivo) and two other districts (Kandreho, and Benenitra) not surveyed during the baseline were subsequently added to the follow-up survey, to achieve national coverage.

[12] The survey used clustered based sampling, with three strata that varied according to location (rural/urban) and population size. In the first stage a random sample of 420 communities (Fokontany) was drawn within each district. In the second stage, a census of all households was conducted and a random draw of 35 households containing at least one child aged 0-5 and/or a pregnant woman was selected.

[13] Forty-six clusters/communities were added in 2004, to include the three districts not interviewed at baseline and ensure national representation. We disregard them from the analysis.

The core instrument with the same format as in the baseline was administered to 24 households within each cluster. The large sample of 10,700 households enables estimation of the malnutrition rate at the district level. Half of the selected households per village, (total of 5350 households nationally) were in addition administered a more in-depth questionnaire. The core questionnaire was expanded to include a female module with in-depth questions on knowledge and practices. The questions cover pregnancy and child care adapted from the Demographic and Health Survey (DHS) in order to capture intermediate indicators that are likely to be affected by the program. Females and the community nutrition worker in participating communities received separate survey instruments with specific questions about the program.

We complement the anthropometric surveys with two additional sources of census-based data. The first one is the Commune Census data, conducted in 2001 under a joint collaboration between Cornell University, the National Statistical Institute (INSTAT) and the agricultural research institute within the Ministry of Scientific Research (FOFIFA). The census contains detailed information on demographic and socio-economic characteristics of all communes in the country, such as remoteness, main economic activities, local infrastructure, and a detailed history of weather shocks[14]. Second, we use commune level estimates[15] of poverty from the poverty map developed by Mistiaen et al (2002) by combining the 1993 household survey with the 1993 population census. The technique allows estimating consumption-based measures of poverty and inequality at very low level of geographic disaggregation. Mistiaen et al (2002) document a considerable degree of spatial heterogeneity in poverty across administrative units within provinces in particular across districts.[16]

### *3.1. Nutritional outcomes*

A summary description of nutrition status at both baseline (1997/98) and follow-up (2004) is presented in Table 1, and summarized in Figure 1 and Figure 2. The two graphs reproduce non-parametric age profiles of weight for age (Figure 1) and height for age (Figure 2), as in Shrimpton et al (2001). The shapes of the graphs confirm the international evidence.

[14] The Census covers 1385 (out of a total of 1394) communes in the country in 2001. The missing communes could not be reached because of the local security reasons. The questionnaire was administered to a focus group composed of residents of the commune.

[15] The Communes were introduces in 1995, replacing Firaisanas as the smallest administrative unit. In order to create communes, some of the Firaisanas were subsequently split or changed some of the boundaries. Our unit of analysis is the community: we are able to assign all communities to old Firaisanas/new Communes with the help of a geographic mapping provided to us by the Statistical Institute.

[16] The fact that the poverty map dates back to 1993, might raise the concerns of its relevance to the current study. However, the national rankings of communes did not change substantially over this period.

First, as documented by Table 1, the program had targeted areas with higher initial malnutrition rates. As a consequence, program areas started off with worse nutritional outcomes at baseline: the continuous line representing the nutritional status in program areas at baseline is strictly below (further away from zero) for both weight/age (Figure 1) and height for age (Figure 2) relative to non-Seecaline communities.

Second, the movements of weight for age and height for age are quite similar until the age of 12 to 18 months, with the largest vertical drop up until 18 months. The decline in weight for age recovers at around 24 months. Height for age decreases until the age of three years, after which there is no recovery from stunting. The shape of both curves, and most notably the focus on the age window where the vulnerability of children to growth faltering is the highest, has been widely used to advocate early nutrition interventions. What is left unexplained is the fact that the gradient of the curve is not only determined by biological factors, but can be influenced by factors such as untreated illnesses during pregnancy, exposure to infections, poor diet and reduced breastfeeding. The underlying motivation behind the SEECALINE intervention is that these factors can be partially redressed through changes in practices during this age window.

Third, the trends over time by program and non-program areas are suggestive of potentially significant program effects of both short and long term nutritional outcomes. It is evident that in 2004, the entire weight/age curve (dashed lines) shifted upwards in program areas, bringing it close to the levels of the non-Seecaline areas. Although height-for-age, a measure of long-term nutritional status, showed deterioration over time in both, program and non-program areas for all cohorts up to age four, this worsening trend is only mildly observed in program areas. It is also notable that these mean changes over time mask important differences across socio-economic groups, as for instance by the education level of the mother (figure 3). Both participant and non-participant areas exhibit an education gradient in nutritional outcomes. It is notable that, over time, more educated mothers stand to gain the most and substantially more so in program areas.

## 4. The Empirical Methodology

The key parameter to be estimated in this paper is the offer of the program to the community, or the so-called ‘intention to treat’ parameter (ITT hereafter). This parameter combines the effect of the program on participants as well as the lack of effect on non-participants in program participating communities. The longitudinal design (at a community level) of the follow-up survey, coupled with a rich set of socio-economic and geographic characteristics allows us to carefully account for the non-random selection of villages into the program, and difference-out any time-invariant component of the selection bias. This allows us to credibly estimate the causal effect of the availability of the program at the community level on individual level outcomes.

The effect of the program on its participants is more difficult to estimate. Participation of mothers could range from active participation to the growth monitoring activities to a simple exposure to the messages in nutrition education and monthly meetings. Non-participants might be benefiting simply by peer effects, or learning from participants. We avoid modeling the extent of participation to the program or potential spillover effects. Under the assumption that the impact of participants is positive and higher than the one on non-participants (less than complete spillover effect), the ITT provides a conservative estimate of the impact of the program, being a lower bound on the impact of the program on the 'treated'.

Each child can be potentially exposed to a program in her community. Let $D_v \in \{0,1\}$ indicate whether a given community ever participates in the program. The potential outcomes for child *i* in village *v* of being exposed to the program at time *t* are denoted as $Y_{1iv,t}$ and $Y_{0iv,t}$. The standard difference in difference (DD) estimator assumes that any correlation between the unobservables and the availability of the program $D_{v,t}$ arises from additive time-invariant village characteristics $\mu_v$, or:

$$E[Y_{0,t} - Y_{0,t'} \mid D = 1] = E[Y_{0,t} - Y_{0,t'} \mid D = 0]$$

Under this assumption, the standard difference in difference (DD) estimator from the following regression:

$$Y_{iv,t} = x_{iv,t}\beta + \alpha D_v * After_t + \delta After_t + \gamma D_v + \mu_v + \varepsilon_{iv,t} \qquad (1)$$

will consistently estimate $\alpha$, the average gain due to the program. The fixed effects at the village level will difference out any unobserved village level component ($\mu_v$) that might be correlated with program placement in the community. Note that while the difference in difference estimate above ($\alpha$) is represented as a constant (common effect model), we will later allow heterogeneity of impacts across communities or households by re-estimating the same regression by the relevant socio-economic subgroup, i.e. allow $\alpha$ to vary according to $X_{iv}$.

However, an important concern about the parallel trend assumption and the standard double difference estimator arises when the program targets poor areas [Ravallion, Chen 2005, Chen et al 2006]. As it is in the case of Seecaline, the program was targeting areas with higher malnutrition rates and lower endowments. If these characteristics affecting program placement also influence the subsequent growth rate of nutritional outcomes, then the DD estimator is sensitive to the functional form assumption [Heckman 1996, Heckman, Lalonde, Smith 1998, Abadie 2005, Ravallion 2006].[17,18]

To address this concern, we combine regression methods (and DD specifically) with a weighting approach following Hirano, Imbens and Ridder (2003), adjusting for differences in covariates by weighting on the inverse of the non-parametric estimate of the estimated propensity score $P(X)$ [19]. The key identifying assumption of conditional independence can be re-written as:

$$E[Y_{0,t} - Y_{0,t'} \mid D_t = 1, P(X)] = E[Y_{0,t} - Y_{0,t'} \mid D_t = 0, P(X)]$$

Which now assumes that selection bias is time invariant conditional on those initial conditions ($X$) that affect the assignment of the program to a community. Implementing this method is equivalent to estimating equation (2) using weights $1/\hat{P}(X)$ for participating villages and $1/(1-\hat{P}(X))$ for non-participant ones.

## 5. Results

### *5.1. The effect of the program on nutritional outcomes*[20]

Table 2 presents the results based on the longitudinal sample of communities and estimates of the intention to treat effect of the program availability on a set of nutritional outcomes.[21]

The effect of the program, defined as having Seecaline in the community (ITT) can be read as the interaction between program and follow-up survey (difference-in-difference). In the OLS specifications presented in Table 2 the coefficient on the project dummy provides the initial differences at baseline for the various outcomes of interest. Seecaline communities indeed started from lower initial conditions, with 4.6 percentage (pct) point higher incidence of stunting, and 8 points higher underweight incidence at baseline. The initial differences are also reflected in the average weight and height z-scores, with a difference of about 0.2 SD

[17] Heckman et al (1998) show that methods that combine matching with DD help control for the heterogeneity in initial conditions and contribute to a substantial reduction in the bias.

[18] Another potential concern invalidating the DD estimator is the possibility that the program is placed based on transitory shocks to communities. From our knowledge of the program assignment, we know that a subset of districts (about 10%) was subsequently added as a response to the occurrence of cyclones and droughts. These shocks however are observed and therefore belong to the list of observable covariates in the analysis.

[19] Following Rosenbaum and Robin (1983), if treatment and potential outcomes are independent conditional on all covariates, they are also independent conditional on the probability of receiving the program given the covariates *P(X)*.

[20] The estimation of propensity score, balancing of differences in the village characteristics and the trimming is described in the appendix along with the results.

[21] The design of the survey first stratifies the sample on provinces and urban/rural location and then randomly sampled the enumeration areas (EAs) at the village level within these strata. Within each EA households were randomly selected. Therefore all errors are clustered at the village level.

lower scores at baseline. The OLS results show that program communities managed to bridge the initial disadvantages in underweight: the estimated effect is of about 7.6 pct points in moderate underweight. It is interesting to note that over the seven years between the baseline and follow-up surveys, the estimates confirm 2.5 pct point positive trend for stunting and a 1.9 pct negative trend for underweight. The differences in the underlying trends for underweight and stunting are important. Underweight is a combination of short and long term nutritional outcomes. The indicator is nonetheless sensitive to sudden weight losses by children: these changes are more visible to mothers, as children who have recently faced a decrease in food intakes or a serious illness. On the other hand, stunting typically reflect a poor diet quality and chronic illnesses (Frongillo et al 1997). Improvements in underweight might not be mirrored by improvements in stunting if the former are not accompanied by cumulative improvements in income and diet quality and consumption. We conjecture that the negative trend could be accounted for, by lack of significant economic growth throughout the period coupled with a sequence of severe weather shocks (in 2000 and 2004) and a political crisis in 2002. The positive and significant effects on both stunting and height/age z-scores for Seecaline communities simply compensated in size for this negative trend that would have occurred in the absence of the program. In short, the availability of the nutrition program helped improve short term nutritional outcomes and helped protect participating communities from worsening their long term outcomes.

Our preferred results based on community fixed-effects regressions with weighting on the inverse of a propensity score confirm the basic OLS results (Table 2). Overall we find significant effect of the program on all nutritional outcomes. When we compare the OLS estimates with the DD we find that weighting reduces the program effect on weight-for-age by 0.069 SD (32% less than the OLS effect), while increasing the magnitude of the trend. There is virtually no change in height-for-age and stunting due to weighting. This is indicative that our weighting strategy improves the selection of comparable control villages. Change over time in the weight-for-age is more susceptible to higher initial malnutrition rates, which can recover partially even in the absence of the program. Our interpretation is that as a cumulative stock variable height is less susceptible to such mean reverting fluctuations and therefore less sensitive to the propensity score weighting.

All our estimation specifications condition on covariates that are present in both the baseline and follow-up surveys, namely age, gender, birth order of the child, education of the mother[22] and regional controls. What is interesting to note is that boys have a worse health status than girls[23]. The other determinants of nutritional status have the expected sign. Children living in urban areas, older cohorts, and children from less educated mothers have on average lower nutritional status and higher malnutrition rates.

### *5.2 Observed heterogeneity in the effect of the program on nutritional outcomes*

Table 3 presents the results of the impact disaggregated according to education levels of the mother. The first four columns present the results on nutritional outcomes using our preferred estimate of difference-in-differences combined with weighting estimated on each education sub-sample. First, note that the underlying trends for the target population differ systematically across different education groups: the positive trends for short term nutritional outcomes (weight for age z-scores and underweight) are observed only for more educated mothers, while the worsening trend in stunting is concentrated among the illiterate mothers. Importantly, these differential trends and widening socio-economic disparities are reinforced when we look at the program effects. More educated mothers are better placed to reap the benefits from the program: mothers with secondary or higher education have an effect that is almost three times as high (-12 pct in moderate malnutrition compared with unschooled and primary schooled mothers (-4 and -3.5 pct respectively).

Column 1 of Table 4 disaggregates the nutritional gains according to socio-economic characteristics of the intervention areas. In the communities that are better-off (which are in the lowest tercile of poverty incidence), more accessible (national/provincial road) and those that have better infrastructure (presence of secondary schools and hospitals, access to safe water) exhibit on average larger gains from the program. The review of heterogeneity of the program effect suggests a conclusion, that although the program explicitly targeted the poorest and more malnourished areas of the country, it is the relatively better-off households and villages which are better placed to translate these gains in the intermediate indicators into gains in nutritional outcomes.

### *5.3 The effect of the program on child care practices*

The intermediate indicators on child practices observed post-program in 2004 provide suggestive evidence regarding the channels for the improvements in nutritional outcomes. This data limitation prevents us from applying the differencing over time at the community level to remove any of the time-invariant components of the selection bias. The propensity

[22] The regression coefficients on the controls are excluded from the tables for sake of exposition but are available upon request.

[23] The pattern seems to be consistent across countries. The explanation put forward is generally biological: boys are believed to be less robust, especially at young ages, and exhibit higher mortality rates by year one, even in developed countries like the US (personal communication with Harold Alderman).

score weighted single difference estimator (SD) implies a stronger identification assumption that all differences in the outcome are due to observable characteristics. If the difference between DD and SD is positive (negative), then SD will under-estimate (over-estimate) the effect of the impact of the program bias due to unobserved heterogeneity. However, due to purposive placement, a naïve comparison between communities with and without the program is likely to be biased and simply capture unobserved community characteristics that are correlated with the availability of the program.

We make two assumptions in interpreting the SD: if (i) 'good practices' are positively correlated with nutritional outcomes as documented in the nutrition literature (Ruel and Menon, 2002) and if (ii) the program targeted communities with worse nutritional outcomes to begin with, then the SD will conservatively underestimate the program effect. While our main results are centered on nutritional gains using the preferred specification of weighted DD, we are still interested in providing suggestive evidence about gains in practices, which suggests the pathways of behavioral changes that generated the gains.

The improvements on nutritional outcomes were achieved through important changes in various dimensions of child care practices (Table 5). Children in participating communities exhibited significant gains in traditional feeding practices: they are more likely to experience exclusive breastfeeding during the first 6 months[24], pre-lacteal feeding, and initial breastfeeding within one hour of birth, and to be breastfed for longer periods. They are also more likely to be provided with more active and responsive feeding, in line with project objectives (in terms of preparing a special meal, with the appropriate consistency). There are also significant signs of behavioral change in hygiene practices, with more appropriate disposal of garbage, toilet use, and improved methods of water purification, all of which reduce the likelihood of water and food contamination and, as a consequence, the vulnerability to environmental diseases and shocks. Finally, they are more likely to have been provided a health card, which (besides vaccinations) represents an important record of the growth trajectory of the child, and contains an introductory section where the key messages on correct practices are provided to mothers.

In Table 3 we focus on a subset of key practices measured in the survey for each educational group. The results suggest that the less educated mothers are relatively more likely to have responded in terms of improved practices. Similarly when we disaggregated impact on

[24] Exclusive breastfeeding for the first 6 months is identified as the single most effective preventive intervention, and provides irreplaceable source of nutrition. Breastfeeding protects against infections, promotes physical, motor, and cognitive development. (Fewtrell 2004)

practices based on village characteristics, we find that better-off villages do exhibit positive impact. This provides us with the suggestive evidence to rule out lack of behavioral response among less educated mothers and in the worse-off areas in accounting for the heterogeneity of program effect in the nutritional outcomes. In conclusion, we provide suggestive evidence that the program disseminated information and that the mothers acted on that knowledge with improved practices.

### *5.4 Discussion of observed heterogeneity: interplay between maternal education and village characteristics*

The economic literature on effects of maternal education on children's nutritional outcomes has argued that the main pathway for the positive health effect can be attributed to acquisition of knowledge. In many instances it has been shown that, knowledge explains the largest share or all of the correlation between education and nutritional outcomes (Christiansen and Alderman 2004, Webb and Block 2004, Glewwe 1999, Thomas et al. 1990). As a measure of maternal knowledge Thomas et al 2004 proxy access to information by exposure to media, Christiansen and Alderman 2004 use mother's capacity to correctly diagnose child growth, Webb and Block 2004 use maternal knowledge of vitamin A importance. This literature does not address the multi-dimensional role of knowledge of practices. Furthermore, maternal knowledge, education and children's nutritional status are jointly determined, and despite attempts, this endogeneity in the estimation of the reduced form of the health production function may not have been resolved. By using the program induced variation in information provision this study contributes to this literature by showing that education and direct knowledge of care practices may in fact play a complementary role to each other.

The channels for these complementarities maybe manifold, for instance education may provide better access to resources, public services and also enable more efficacious adoption of practices. When we further estimate interaction effects between mother's education and village characteristics (table 6), we find that within worse-off areas better educated mothers exhibit positive gains. For instance in least poor areas gains are accrued across educational groups, but in poorest areas gains accrue only to children of educated mothers. This result is robust to various dimensions of socio-economic backwardness, the same pattern is reflected when we look at the program effect for each educational level by remoteness or access to public services such as hospital and electricity. Education thus compensates for poor environment and enables behavioral change to translate into nutritional gains suggesting one possible channel for the complementarities between education and knowledge of care.

## 6. Discussions and Conclusions

In this paper, we provide rigorous evidence on effects of a large scale policy aimed at improving care practices for a sustained period on children's nutritional outcomes in Madagascar. We also document the channels of behavioral change affected by the program.

Previous literature has shown a strong correlation between knowledge of nutritional care and nutritional outcomes. These studies typically subsume the key element of self-efficacy – a woman's belief that she can act on what she has learned given her environmental constraints. In contrast to previous literature, our results are identified from the program induced variation. We document that better child-care knowledge leads to behavioral response and find robust causal evidence that the improved knowledge can enhance nutritional outcomes on a large scale.

The program aims at targeting the poorest and more malnourished areas. If information is a key barrier to changing nutritional outcomes - what are the characteristics of those households that stand to gain the most from this intervention within those areas? Are there any differences in the characteristics of households in changing practices and in how these changes in practices translate into improved nutritional outcomes? Our results show important socio-economic gradients in terms of improvements in practices and nutritional outcomes. Worst-off households are more likely to have gained in terms of adoption of child care practices. However, this same socio-economic group has greater difficulties in translating the improved practices into improvements in nutritional outcomes. Less educated mothers and worse-off households have exhibited over time the worst trends, and, in addition, were less placed to benefit from the program in terms of nutritional outcomes. They have lower endowments that are important complementary inputs to knowledge and practices in the health production function of children (for instance better quality of nutrients and access to safe water). Overall, both sets of results provide a consistent picture with substantial heterogeneity in the returns to availability to the program across different socio-economic groups in the population. As often shown in the literature (Ruel et al, 2002) the socio-economically worse-off groups tend to gain more from improved knowledge. We find that the extent of improvement from the intervention depends on the conditions of living environment such as poverty, access to public services and remoteness. Therefore, even though knowledge is necessary, it may be insufficient for improving outcomes in the households that are limited in access to complementary resources and in their ability to act on it.

There are important questions that are still left unanswered and we are planning to explore them in future work. We are mute on the possibility that lower educated mothers may also have lower levels of self-efficacy. This may be underscored if the reported behavioral response is misreported by mothers in program areas as it is often pointed out that self-reported behavior maybe indistinguishable from changes in norms and attitudes. Furthermore, we are missing information on quality of adoption that could also lead to similar pattern of gains by education. Exactly how these behavioral measures change (in a causal sense) due to the intervention remains a topic of our ongoing research. The necessary data are just now becoming available. In poor countries where the absolute level of living conditions is low, availability of a community based nutrition program in the village has nonetheless an important role in protecting the long term nutritional status of children during their critical age.

**References:**


Alderman H., (2007) "Improving Nutrition through Community Growth Promotion: Longitudinal Study of the Nutrition and Early Child Development Program in Uganda", World Development, 35: 1376-1389.

Alderman H., J., Hoddinott and B. Kinsey (2006) "Long Term Consequences Of Early Childhood Malnutrition", *Oxford Economic Papers*, 58: 450-474.

Allen L. and S.Gillespie (2001) "What Works? A Review of Efficacy and Effectiveness of Nutrition Interventions", Asian Development Bank, Nutrition and Development Series # 5.

Behrman J. (1996) "The Impact of Health and Nutrition on Education", *World Bank Research Observer,* 11(1): 23-39.

Berg, A. (1987) *Malnutrition: What can be done?*, The World Bank, Washington D.C.

Chen, Mu, Ravallion (2006) "Are There Lasting Impacts of Aid to Poor Areas? Evidence from Rural China", World Bank Policy Research Working Paper 4084, The World Bank.

Currie J. and D. Thomas (1995) "Does Head Start Make a Difference?" *American Economic Review,* 85(3): 341-364.

Favin, M. and M. Griffiths (1999) *Communication for Behavior Change in Nutrition Projects*, Nutrition Toolkit Module No. 9, Human Development Network, the World Bank http://www.micronutrient.org/idpas/pdf/2019CommunicationFor.pdf

Frongillo, J.E., M. de Onis, K. Hanson (1997) "Socioeconomic and Demographic Factors are Associated with Worldwide Patterns of Stunting and Wasting", *Journal of Nutrition*, 127(12): 2302-2309.

Galasso, Emanuela and Jeffrey Yau (2006), "Learning through monitoring : lessons from a large-scale nutrition program in Madagascar", Policy Research Working Paper no. 4058, The World Bank.

Gillespie S., J. Mason, and R. Martorell (1996) "How Nutrition Improves", ACC/SCN Nutrition Policy Discussion Paper No. 15, UN ACC/SCN, Geneva. http://www.unsystem.org/scn/archives/npp15/index.htm

Gillespie S., M. McLachlan and R. Shrimpton eds. (2003) *Combating Malnutrition. Time to Act*. World Bank, Washington DC

Grantham-McGregor S., L. Fernald and K. Sethuraman (1999) "Effects of Health and Nutrition on Cognitive and Behavioural Development in Children in the First Three Years of Life. Part 1. Low Birth weight, Breastfeeding and Protein-energy Malnutrition", *Food and Nutrition Bullettin*, 20(1): pp. 53-75.

Haddad L., et al (2003) "Reducing Malnutrition: How Far does Income Growth take us?", *World Bank Economic Review,* 17: 107-131

Heckman J., H. Ichimura, J. Smith and P. Todd (1998) "Characterizing Selection Bias using Experimental Data", *Econometrica,* 66(5): 1017-98.

Heckman, J., R. Lalonde and J. Smith (1999), "The Economics and Econometrics of Active Labor Market Programs", *Handbook of Labor Economics,* Volume 3, Ashenfelter, A. and D. Card, eds., Amsterdam: Elsevier Science.

Heckman, J. (2006) "Investing in disadvantaged Young Children is an Economically Efficient Policy", paper presented at the Committee for Economic Development, The Pew Charitable Trusts, New York.

Heckman, J., E. Vytlacil (2006), "Econometric Evaluation of Social Programs", chapter in the *Handbook of Econometrics*, Volume 6**,** J. Heckman and E. Leamer (eds), North Holland: Amsterdam, forthcoming.

Imbens, G., K. Hirano and G. Ridder (2003) "Efficient Estimation of Average Treatment Effects using the Estimated Propensity Score", *Econometrica* 71, 1161-1189.

Jalan, Jyotsna, and Martin Ravallion (2003) "Does Piped Water Reduce Diarrhea for Children in Rural India?" *Journal of Econometrics*, (112) :153–73.

Mistiaen, J. A., B. Ozler, T. Razafimanantena, and J. Razafindravonona. (2002), "Putting Welfare on the Map in Madagascar." Technical report, African RegionWorking Paper no. 34, World Bank, Washington, DC.

Ravallion, M. (2006) "Evaluating Anti-Poverty Programs", Policy Research Working Paper no. 3625, The World Bank, Washington D.C.

Ross, J. (1997) "Cost-effectiveness of the Nutrition Communication Project in Mali." SARA Project (AED): Washington, D.C.

Ruel, M.T. and P. Menon (2002) "Child feeding practices are associated with child nritional status in Latin America: Innovative uses of the Demographic and Health Surveys", *Journal of Nutrition* 132, 1180-1187.

Ruel, M.T., Levin, C.E., Armar-Klemesu, M., Maxwell, D.G. and S.S. Morris (1999) "Good care practices mitigate the negative effects of poverty and low maternal schooling on children's nutritional status: evidence from Accra**",** *World Development* 27 (11): 1993-2009

Salehi, M., S.M. Kimiagar, M. Shahbazi, Y. Mehrabi and A.A. Kolahi (2004) "Assessing the impact of nutrition education on growth indices of Iranian nomadic children: an application of modified beliefs, attitudes, subjective-norms and enabling-factors model", *British Journal of Nutrition*, 91, 779-87.

Save the Children (2003) "Thin on Ground: Questioning the evidence behind World-Bank funded community nutrition projects in Bangladesh, Ethiopia and Uganda", London, UK.

Shaikh, A., M.Simonsen, Vytlacil, E., and N. Yildiz (2005) "On the Identification of Misspecified Propensity Scores", mimeo, Columbia University, Department of Economics.

Shrimpton R. et al (2005) "Worldwide Timing of Growth Faltering: Implications for Nutritional Interventions", *Pediatrics*, 107(5).

Thomas, D., Strauss, J., and M., Henriques (1991) "How does mother's education affect child height?", *Journal of Human Resources*, 26.2:183-211

USAID (1988) "Growth Monitoring and Nutrition Education: Impact Evaluation of an Effective Applied Nutrition Program in the Dominican Republic", CRS/CARITAS, 1983–1986. Washington, D.C.

World Health Organization (2003) *Global Strategy for Infant and Young Child Feeding,* http://www.who.int/nut/documents/gs_infant_feeding_text_eng.pdf

The World Bank (2006) *Repositioning Nutrition as Central for Development. A Strategy for Large-Scale Action.*

**Figure 1. Age profiles of weight for age z-scores, baseline and follow-up, by treatment status**

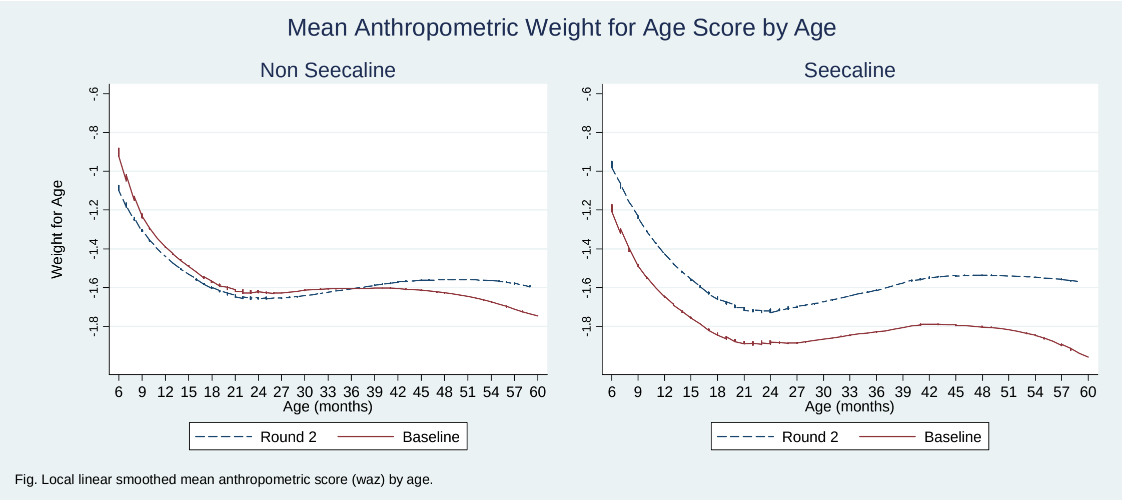



**Figure 2. Age profiles of height for age z-scores, baseline and follow-up, by treatment status**

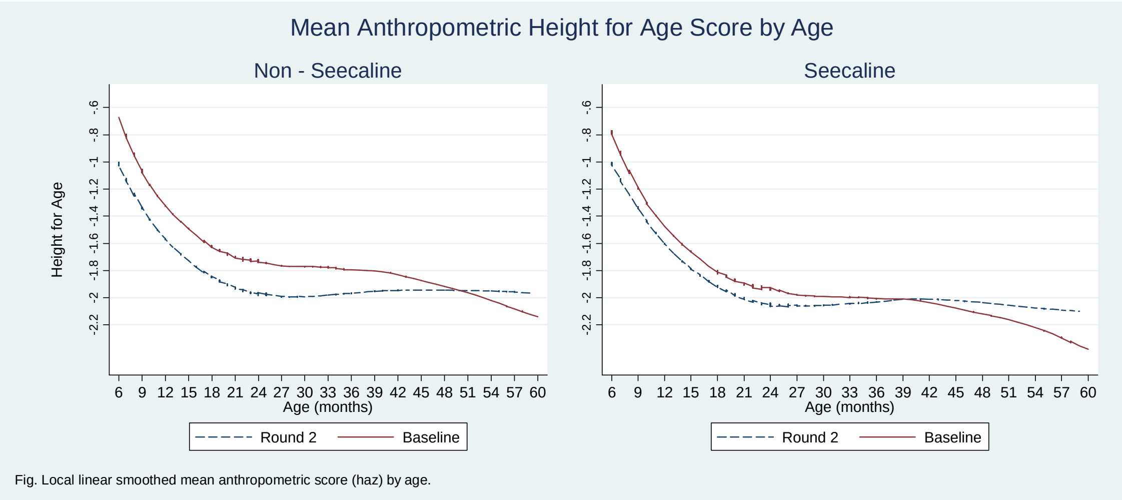


**Figure 3. Age profiles of weight for age z-scores, baseline and follow-up, by treatment status and mother's education**

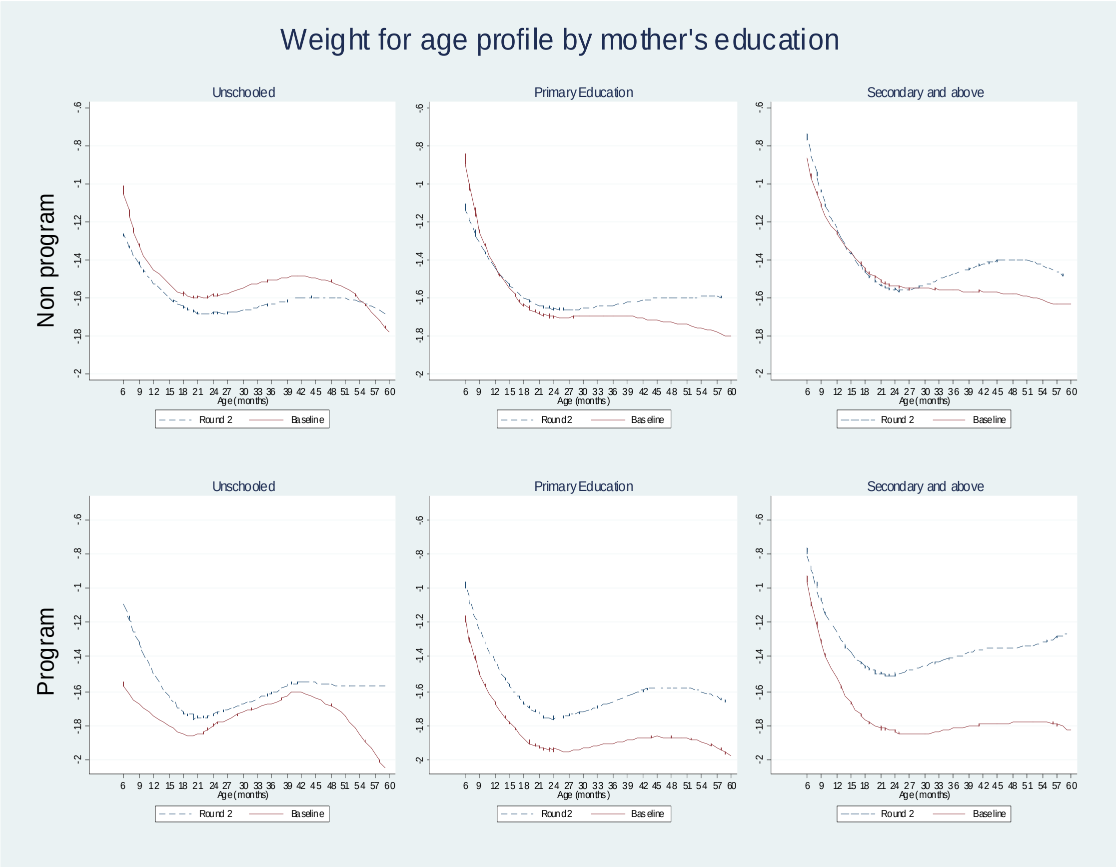


**Table 1: Descriptive statistics, panel sample 1997/98-2004**

| | Baseline 1997-98 | | | | | |
|---|---|---|---|---|---|---|
| | *whole sample* | | *Seecaline communities* | | *non-Seecaline communities* | |
| | mean | *std.err.* | mean | *std.err.* | mean | *std.err.* |
| Height for age z-score | -1.882 | *0.040* | -1.942 | *0.068* | -1.831 | *0.048* |
| Weight for age z-score | -1.723 | *0.025* | -1.789 | *0.047* | -1.667 | *0.028* |
| Underweight (-2SD) | 0.427 | *0.009* | 0.452 | *0.014* | 0.405 | *0.013* |
| Underweight (-3SD) | 0.105 | *0.005* | 0.126 | *0.011* | 0.088 | *0.004* |
| Stunting (-2SD) | 0.475 | *0.011* | 0.490 | *0.018* | 0.463 | *0.014* |
| Stunting (-3SD) | 0.193 | *0.007* | 0.207 | *0.013* | 0.180 | *0.009* |
| No. obs. | 18,177 | | 6,761 | | 11,416 | |
| | Follow-up 2004 | | | | | |
| Height for age z-score | -1.974 | *0.028* | -2.017 | *0.039* | -1.943 | *0.039* |
| Weight for age z-score | -1.584 | *0.020* | -1.599 | *0.031* | -1.574 | *0.027* |
| Underweight (-2SD) | 0.350 | *0.008* | 0.357 | *0.013* | 0.344 | *0.011* |
| Underweight (-3SD) | 0.074 | *0.004* | 0.076 | *0.006* | 0.072 | *0.005* |
| Stunting (-2SD) | 0.491 | *0.009* | 0.506 | *0.014* | 0.479 | *0.012* |
| Stunting (-3SD) | 0.188 | *0.006* | 0.192 | *0.010* | 0.184 | *0.009* |
| No. obs. | 12,367 | | 4,480 | | 7,887 | |

Note: Anthropometrics measures calculated using sampling weights. Individual sample using all 420 panel clusters/communities interviewed in both survey years.

**Table 2: ITT panel sample: z-scores**

| | Weight for age z-score | | Height for age z-score | | Moderate Undernutrition (-2SD) | | Moderate Stunting (-2SD) | |
|---|---|---|---|---|---|---|---|---|
| | OLS | Community Fixed Effects† | OLS | Community Fixed Effects | OLS | Community Fixed Effects | OLS | Community Fixed Effects |
| Program*year 2004 | 0.218*** | 0.149*** | 0.119** | 0.094* | -0.075*** | -0.052*** | -0.025 | -0.030* |
| *Sd* | *0.046* | *0.049* | *0.050* | *0.056* | *0.017* | *0.018* | *0.016* | *0.017* |
| Program | -0.220*** | | -0.173*** | | 0.080*** | | 0.046** | |
| | *0.038* | | *0.049* | | *0.014* | | *0.014* | |
| Year: 2004 | 0.022 | 0.063** | -0.041 | -0.003 | -0.019* | -0.037*** | 0.025* | 0.018 |
| | *0.025* | *0.028* | *0.031* | *0.035* | *0.010* | *0.011* | *0.010* | *0.011* |
| No. obs. | 29,911 | 23,333 | 29,211 | 22,828 | 29,795 | 24,279 | 28,675 | 23,368 |
| R2 | 0.031 | 0.027 | 0.047 | 0.043 | 0.021 | 0.018 | 0.033 | 0.028 |

Note Standard deviations based on Huber-White robust standard errors clustered at the community level. Significantly different at * 90%, ** 95%, *** 99%. Subsumed regressors are age and birth order dummies, gender, education level of the mother (and for OLS rural indicator).
†The community fixed effects specification is based on a pscore weighted and trimmed in the [0.05, 0.95] interval sample.

**Table 3: ITT panel sample: nutritional outcomes by education level of the mother**

| | Weight for age z-score | Height for age z-score | Underweight (-2SD) | Stunting (-2SD) | Exclusiv. BF first 6m | meal: puree/ boiled | Toilet: hole in the ground |
|---|---|---|---|---|---|---|---|
| *Program effects by subgroup:* | **Panel sample** | | | | **Cross-sectional sample** | | |
| Unschooled | 0.130 | 0.033 | -0.040 | -0.010 | 0.359*** | 0.377** | 0.095 |
| | *(0.085)* | *(0.117)* | *(0.033)* | *(0.033)* | (0.118) | *(0.170)* | *(0.176)* |
| Primary | 0.133** | 0.097 | -0.035 | -0.020 | 0.179** | 0.209** | 0.294** |
| | *(0.054)* | *(0.061)* | *(0.023)* | *(0.021)* | (0.078) | *(0.093)* | *(0.119)* |
| Secondary and higher | 0.242*** | 0.140 | -0.127*** | -0.054 | 0.081 | 0.279* | 0.123 |
| | *(0.068)* | *(0.086)* | *(0.030)* | *(0.033)* | (0.110) | *(0.152)* | *(0.169)* |
| *Time trends by subgroup:* | | | | | | | |
| Unschooled | 0.001 | -0.108 | -0.012 | 0.042** | | | |
| | *(0.052)* | *(0.069)* | *(0.022)* | *(0.021)* | | | |
| Primary | 0.097*** | 0.037 | -0.047*** | 0.014 | | | |
| | *(0.032)* | *(0.044)* | *(0.014)* | *(0.014)* | | | |
| Secondary and higher | 0.101*** | -0.000 | -0.035** | -0.006 | | | |
| | *(0.039)* | *(0.051)* | *(0.017)* | *(0.019)* | | | |

Note: Each line report the coefficients from a separate regression run on each different subgroup. In parentheses are standard deviations based on errors clustered at the village level. All reported results are PS weighted estimates on the trimmed sample. Significance level: .01 - ***; .05 - **; .1 - **

**Table 4: ITT - heterogeneity according to village level characteristics**

| Program Effect by subgroup | Weight/age z-scores* | Exclusiv. BF first 6m | meal: puree/ boiled | Toilet: hole in the ground |
|---|---|---|---|---|
| | *Zone* | | | |
| Rural | 0.160*** | | | |
| | *(0.050)* | | | |
| Urban | 0.119 | | | |
| | *(0.093)* | | | |
| | *Poverty* | | | |
| Lowest tercile | 0.330*** | 0.156 | 0.306** | 0.288 |
| | *(0.082)* | *(0.106)* | *(0.121)* | *(0.221)* |
| Middle tercile | 0.001 | 0.155 | *0.223* | 0.045 |
| | *(0.078)* | *(0.111)* | *(0.138)* | *(0.178)* |
| Upper tercile | 0.144** | 0.402*** | 0.213* | 0.290* |
| | *(0.069)* | *(0.100)* | *(0.125)* | *(0.170)* |
| | *Proximity of rural road* | | | |
| Yes | 0.246*** | 0.247*** | 0.123 | 0.407** |
| | *(-0.060)* | (0.092) | *(0.123)* | *(0.168)* |
| No | 0.053 | 0.220** | *0.277**** | *0.047* |
| | *(-0.064)* | (0.095) | *(0.104)* | *(0.155)* |
| | Secondary school | | | |
| Yes | 0.154*** | 0.208*** | 0.238*** | 0.202 |
| | *(-0.052)* | *(0.073)* | *(0.079)* | *(0.127)* |
| No | 0.154* | 0.137 | 0.218 | 0.338 |
| | *(-0.083)* | *(0.122)* | *(0.175)* | *(0.211)* |
| | *Hospital* | | | |
| Yes | 0.234*** | 0.105 | 0.358*** | 0.079 |
| | *(-0.088)* | *(0.114)* | *(0.135)* | *(0.230)* |
| No | 0.129** | 0.217*** | 0.168* | 0.266** |
| | *(-0.052)* | *(0.077)* | *(0.092)* | *(0.125)* |
| | *Electricity* | | | |
| Yes | 0.210** | 0.218** | 0.253** | 0.222 |
| | *(-0.104)* | *(0.089)* | *(0.104)* | *(0.164)* |
| No | 0.144*** | 0.193** | 0.190* | 0.251* |
| | *(-0.049)* | *(0.090)* | *(0.107)* | *(0.148)* |
| | *Type of Water source in the community* | | | |
| Piped-in water/public fountains | 0.112 | 0.094 | 0.370** | -0.255 |
| | *(-0.083)* | *(0.190)* | *(0.163)* | *(0.246)* |
| Protected wells | 0.206* | -0.240* | 0.065 | -0.192 |
| | *(-0.118)* | *(0.140)* | *(0.209)* | *(0.303)* |
| Unprotected wells | 0.317*** | 0.081 | 0.543*** | 0.532* |
| | *(-0.111)* | *(0.168)* | *(0.175)* | *(0.284)* |
| Spring, rain water | 0.115 | 0.220* | -0.174 | 0.314 |
| | *(-0.114)* | *(0.120)* | *(0.200)* | *(0.236)* |
| River, lake | -0.002 | 0.490*** | 0.437*** | 0.360* |
| | *(-0.084)* | *(0.134)* | *(0.141)* | *(0.192)* |

Note: Each line reports the coefficients from a separate regression. The subsamples of poverty refer to terciles of incidence (headcount index) of the commune where village is residing. The headcount cutoff are (0, 0.67], (0.67, 0.79], (0.79,1]. The subsamples of distance terciles correspond to cutoffs [0,8], [9,28], [29,180]. Below in parentheses are standard deviations based on errors clustered at the village level. All reported results are PS weighted estimates. Significance level: .01 - ***; .05 - **; .1 - **

**Table 5: ITT, cross-sectional sample: child care practices and intermediate outcomes**

| | ITT | *std.dev* | Mean of dep. var in non-program area (PSweighted) |
|---|---|---|---|
| *Micronutrient supplementation:* | | | |
| Received vitamin A supplementation | 0.080 | *0.060* | 0.759 |
| Received message with vitamin A supplement. | 0.128** | *0.064* | 0.571 |
| Having health card (carnet de santé) | 0.265*** | *0.072* | 0.800 |
| *Traditional practices: breastfeeding and weaning* | | | |
| EBF during the first 6 months | 0.201*** | *0.064* | 0.339 |
| initial breastfeeding (within 1 hour of birth) | 0.083 | *0.072* | 0.506 |
| Feeding colostrum (pre-lacteal) | 0.227*** | *0.075* | 0.754 |
| mother is eating more while breastfeeding | 0.064 | *0.064* | 0.126 |
| mother is drinking more while breastfeeding | -0.063 | *0.085* | 0.554 |
| Still breastfeeding | 0.132* | *0.071* | 0.327 |
| No. times child breastfed previous night | 0.208 | *0.186* | 5.022 |
| No. times child breastfed previous day | 0.060 | *0.218* | 7.826 |
| | | | |
| *Non-dietary aspects of feeding:* | | | |
| child eats different meal | 0.272*** | *0.073* | 0.161 |
| child encouraged to eat | 0.113 | *0.079* | 0.795 |
| consistency meal: boiled/puree | 0.219*** | *0.076* | 0.187 |
| child eats alone | -0.094 | *0.068* | 0.614 |
| received nutritional counseling | 0.972*** | *0.074* | 0.326 |
| *Pregnancy:* | | | |
| Received tetanus injection during pregnancy | 0.100 | *0.067* | 0.155 |
| Delivered with medical assistance | -0.023 | *0.073* | 0.529 |
| Received vitamin A after delivery | 0.340*** | *0.061* | 0.288 |
| *Treatment of illness:* | | | |
| incidence diarrhea past 2 weeks | 0.144** | *0.063* | 0.076 |
| received ORS/homemade liquid | -0.088 | *0.147* | 0.379 |
| Drank more during diarrhea episode | 0.058 | *0.152* | 0.400 |
| Ate more during diarrhea episode | 0.564*** | *0.195* | 0.039 |
| *Hygiene practice:* | | | |
| Garbage disposal: hole in the ground | 0.207** | *0.087* | 0.496 |
| Any water purification method: tablets or boiling | 0.183** | *0.083* | 0.356 |
| Toilet: hole in the ground | 0.216* | *0.111* | 0.509 |
| Handwashing | 0.117 | *0.085* | 0.269 |

Note: Standard deviations based on Huber-White robust standard errors clustered at the community level. Significantly different at * 90%, ** 95%, *** 99%. Regression/Probit are PS–weighted on the trimmed sample. Subsumed regressors are: individual (age and birth order dummies, gender, perceived birthweight), mother (log height, education, age, work status), household (size, access to safe water, housing and durable indicators), rural dummy and areas indicators. In addition, the probit regressions related to the treatment of illnesses includes an indicator for the occurrence of a weather shock in the village in the previous three months.

**Table 6: ITT panel sample: Weight for age z-scores by mother's education and village characteristics**

| | **Mother: Unschooled** | **Mother: Primary education** | **Mother: Secondary education or higher** |
|---|---|---|---|
| *Poverty* | | | |
| Lowest Tercile | 0.275* | 0.202** | 0.301** |
| | *(0.151)* | *(0.096)* | *(0.119)* |
| Middle Tercile | 0.048 | 0.059 | 0.098 |
| | *(0.146)* | *(0.097)* | *(0.113)* |
| Upper Tercile | 0.009 | 0.098 | 0.197* |
| | *(0.147)* | *(0.089)* | *(0.110)* |
| *Provincial Road* | | | |
| Present | 0.363*** | 0.198*** | 0.300*** |
| | *(0.119)* | *(0.075)* | *(0.099)* |
| Not Present | -0.054 | 0.063 | 0.160* |
| | *(0.109)* | *(0.080)* | *(0.088)* |
| *National Road* | | | |
| Present | 0.174 | 0.133* | 0.218** |
| | *(0.119)* | *(0.070)* | *(0.098)* |
| Not Present | 0.075 | 0.139 | 0.284*** |
| | *(0.122)* | *(0.086)* | *(0.084)* |
| *Secondary school* | | | |
| Present | 0.111 | 0.161** | 0.205*** |
| | *(0.117)* | *(0.064)* | *(0.075)* |
| Not Present | 0.167 | 0.050 | 0.442*** |
| | *(0.124)* | *(0.091)* | *(0.157)* |
| *Hospital* | | | |
| Present | 0.505*** | 0.173 | 0.259** |
| | *(0.177)* | *(0.109)* | *(0.119)* |
| Not Present | 0.044 | 0.128** | 0.224*** |
| | *(0.096)* | *(0.062)* | *(0.083)* |
| *Electricity* | | | |
| Present | 0.507* | 0.177 | 0.122 |
| | *(0.272)* | *(0.142)* | *(0.126)* |
| Not Present | 0.101 | 0.128** | 0.312*** |
| | *(0.089)* | *(0.058)* | *(0.078)* |

Note: Each line reports the coefficients from a separate regression. Below in parentheses are standard deviations based on errors clustered at the village level. All reported results are PS weighted estimates. Significance level: .01 - ***; .05 - **; .1 - **

## Appendix A

*Propensity Score: methods and estimation*

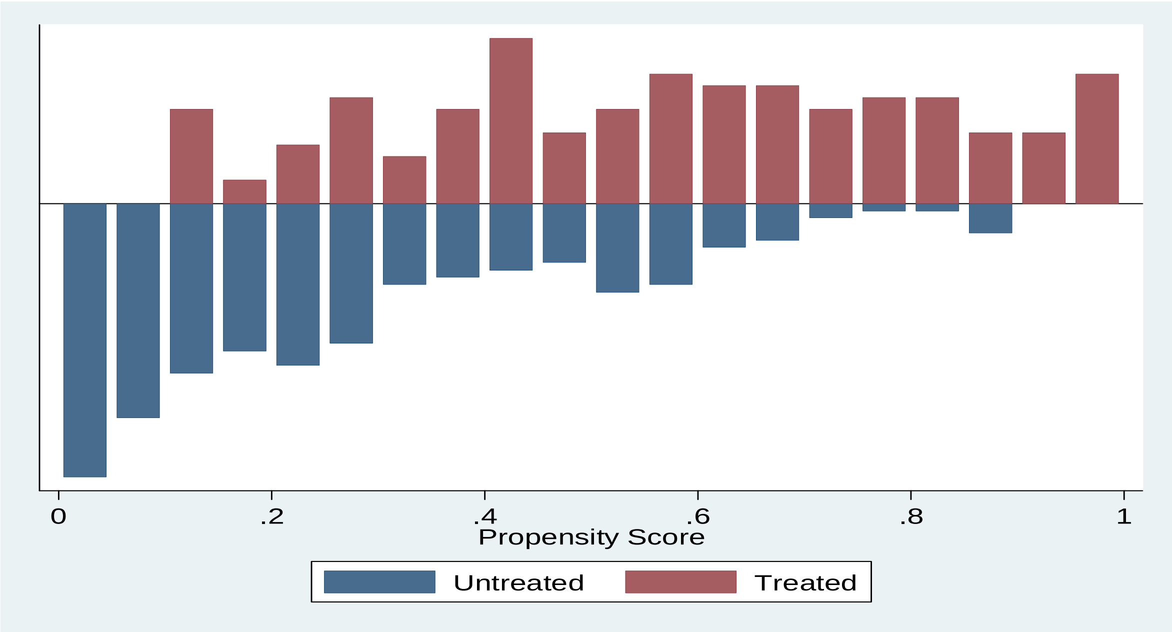
To estimate the propensity score we pool observations from program and non-program areas using a logit regression. Appendix Table 7 gives the results and Figure 4 provides a graph for the estimated propensity score by program and non-program villages. The joint tests for significance emphasize a number of groups of variables that affect program placement. The placement is correlated with eligibility criteria based on initial village malnutrition rates, village size characteristics and geographic location. The program was targeted to poorer and more malnourished areas as evident from Table 8. One important consideration in implementing this method is that one needs sufficient overlap in the distribution of covariates between participating and non-participating villages. Heckman, Ichimura and Todd (1997, 1998) have highlighted this issue of 'common support' as an important component of selection bias. The concern is particularly relevant in the case of programs with geographic targeting (as shown in Ravallion, Chen 2005)[25]. As shown in table 8, trimming helps reduce the difference in standardized means between program and non-program areas, as common with targeted programs. The improvement in precision and consistency in the estimated effects that comes with trimming however comes at a cost of sample representativeness: trimming implies dropping about 14% of the participating communities (20/147) and 22% of the non-participating communities (60/271).

In order to achieve a better balance for covariates we use a specification test for the propensity score introduced by Shaikh et al (2005). We allow for a flexible specification of the propensity score estimation through of inclusion of polynomial terms for the initial eligibility criteria, poverty and remoteness. We also include interactions between eligibility criteria and shocks. Additionally, we test for differences in standardized means of the covariates between the $D = 1$ and $D = 0$ groups after conditioning on $\hat{P}(X)$.

[25] We follow common practice and present estimates that drop all villages with an estimated propensity score outside the interval [0.05, 0.95].

## Appendix B: Figures and Tables

**Figure 4: Distributions of the estimates Propensity Scores by village participation**



## Table 7: Logit regression of village participation in Seecaline

| | Coef | Sd |
|---|---|---|
| *Eligibility* | | |
| Avg underweight (-2SD) | 15.398** | 7.220 |
| ... squared | -15.781** | 8.033 |
| Avg underweight (-3SD) | 28.724* | 14.867 |
| ... squared | -141.021 | 92.796 |
| ... cubed | 263.986 | 172.935 |
| Poverty | 3.427 | 5.424 |
| ...squared | -2.310 | 4.124 |
| *Remoteness* | | |
| Travel time to urban center | 0.024 | 0.045 |
| ...squared | -0.000 | 0.001 |
| ...cubed | 0.000 | 0.000 |
| Near to national highway | 0.584 | 0.367 |
| Availability of a prov road | 0.393 | 0.332 |
| Access to paved road | 0.190 | 0.383 |
| Access to a bus stop | 0.055 | 0.346 |
| Distance to district center | 0.005 | 0.014 |
| ... squared | 0.000 | 0.000 |
| Fokontany next to a road | -0.120 | 0.332 |
| Insecurity zone | -1.123*** | 0.363 |
| *Infrastructure* | | |
| Presence of hospital | -0.135 | 0.546 |
| Presence of high school | -0.028 | 0.430 |
| Electricity | -0.092 | 0.418 |
| Access to portable water | -0.170 | 0.357 |
| Presence of a health post | 0.077 | 0.724 |
| *Main economic activity* | | |
| Main activity: manufacturing | -0.027 | 0.332 |
| Main activity: livestock | -0.421 | 0.785 |
| main activity: commerce | -0.772 | 0.833 |
| main activity: other | 0.157 | 0.718 |
| Daily market | -0.315 | 0.369 |
| Seasonal market | 0.567* | 0.321 |
| Cattle market | 0.598* | 0.359 |
| Bi-weekly market | -0.982*** | 0.379 |
| *Shocks* | | |
| Cyclone in 1999 | 0.200 | 0.376 |
| Cyclone in 2000 | -0.020 | 0.354 |
| Cyclone in 2001 | -0.552 | 0.625 |
| Flooding in 1999 | -0.476 | 0.397 |
| Flooding in 2000 | 1.599 | 1.010 |
| Flooding in 2001 | -0.080 | 0.423 |
| Disrupted road in 1999 | 0.646 | 0.477 |
| Disrupted road in 2000 | 0.049 | 0.414 |
| Disrupted road in 2001 | 0.131 | 0.484 |
| Drought in 1999 | -0.394 | 0.394 |
| Drought in 2000 | -0.233 | 0.411 |
| Drought in 2001 | 0.705 | 0.488 |
| Length of lean season | -0.059 | 0.090 |
| *Size* | | |
| Population(log) commune | 0.096 | 0.299 |
| Population(log) Fokontany | -0.437* | 0.261 |
| No. Fok. in the commune | -0.058*** | 0.023 |
| *Geographic characteristics* | | |
| rural FKT | -0.342 | 0.506 |
| Province: Fianarantosoa | -0.553 | 0.547 |
| Province: Toamasina | -0.071 | 0.577 |
| Province: Mahajanga | -0.049 | 0.673 |
| Province: Toliara | 2.440*** | 0.671 |
| Province:Antsiranana | 0.677 | 0.784 |
| *Baseline avg educ mothers* | | |
| prop.unschooled women | -1.645 | 1.171 |
| ... primary education | 1.372 | 1.130 |
| *Interactions* | | |
| rural* avg underweight (-2SD) | -0.823 | 2.993 |
| rural* avg underweight (-3SD) | -2.659 | 6.481 |
| _cons | -3.971 | 4.203 |
| Number of observations | 374 | |
| Pseudo R2 | 0.274 | |

**Table 8: Comparison of village characteristics with and without weighting and trimming**

| | Standardized Means (0,1) | | Differences in std. Means: Seecaline – Non Seecaline communities | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | | Un-weighted | | PS Weighted | | PS Weighted and trimmed range [0.05,0.95] | |
| | Non-program | Program | Diff | *s.e.* | Diff | *s.e.* | Diff | *s.e.* |
| Average underweight 2SD | -0.211 | 0.377 | 0.588 | *0.099* | 0.429 | *0.089* | 0.314 | *0.094* |
| Average underweight 3SD | -0.209 | 0.374 | 0.584 | *0.111* | 0.395 | *0.094* | 0.272 | *0.096* |
| Time to travel commune nearest urban center (hours) | 0.013 | -0.023 | -0.036 | *0.101* | -0.030 | *0.090* | -0.042 | *0.093* |
| proximity national road | -0.012 | 0.022 | 0.034 | *0.103* | -0.020 | *0.092* | -0.074 | *0.096* |
| proximity provincial road | 0.053 | -0.095 | -0.148 | *0.103* | -0.045 | *0.091* | 0.058 | *0.095* |
| Commune accessible through a paved road | -0.020 | 0.036 | 0.056 | *0.103* | 0.044 | *0.092* | -0.012 | *0.095* |
| Stop train/taxi-brousse | 0.016 | -0.028 | -0.044 | *0.103* | -0.027 | *0.092* | -0.033 | *0.095* |
| Distance Fokontany –district capital | 0.007 | -0.012 | -0.019 | *0.101* | 0.010 | *0.091* | 0.018 | *0.095* |
| Fokontany next to a road | 0.008 | -0.014 | -0.022 | *0.104* | -0.020 | *0.092* | -0.009 | *0.096* |
| Zonerouge (insecurity zone) | 0.107 | -0.193 | -0.300 | *0.098* | -0.200 | *0.090* | -0.151 | *0.094* |
| Presence hospital | 0.061 | -0.109 | -0.169 | *0.100* | -0.155 | *0.090* | -0.156 | *0.094* |
| Presence high school | 0.032 | -0.058 | -0.090 | *0.104* | -0.095 | *0.092* | -0.070 | *0.096* |
| Electricity | 0.089 | -0.160 | -0.249 | *0.102* | -0.170 | *0.091* | -0.163 | *0.095* |
| access to potable water | 0.090 | -0.163 | -0.254 | *0.103* | -0.180 | *0.092* | -0.114 | *0.096* |
| Presence health post | 0.064 | -0.115 | -0.179 | *0.115* | -0.102 | *0.095* | -0.084 | *0.098* |
| main activity: manufacturing | 0.049 | -0.088 | -0.137 | *0.102* | -0.137 | *0.091* | -0.136 | *0.095* |
| main activity: livestock | 0.016 | -0.030 | -0.047 | *0.103* | -0.076 | *0.092* | -0.038 | *0.096* |
| main activity: commerce | 0.020 | -0.036 | -0.056 | *0.101* | -0.037 | *0.091* | -0.028 | *0.095* |
| main activity: others | 0.022 | -0.041 | -0.064 | *0.099* | -0.042 | *0.090* | -0.078 | *0.093* |
| seasonal market | 0.077 | -0.138 | -0.215 | *0.104* | -0.168 | *0.092* | -0.115 | *0.096* |
| cattle market | 0.012 | -0.022 | -0.034 | *0.103* | 0.010 | *0.092* | -0.012 | *0.095* |
| bi-weekly market | 0.043 | -0.077 | -0.120 | *0.102* | -0.058 | *0.091* | -0.060 | *0.095* |
| Daily market | 0.124 | -0.224 | -0.349 | *0.106* | -0.245 | *0.092* | -0.136 | *0.096* |
| Ever had cyclone | -0.051 | 0.094 | 0.145 | *0.103* | 0.085 | *0.099* | 0.049 | *0.010* |
| Ever flooded | -0.109 | 0.201 | 0.310 | *0.100* | 0.261 | *0.097* | 0.145 | *0.010* |
| Ever roads disrupted | -0.032 | 0.058 | 0.090 | *0.102* | 0.068 | *0.099* | 0.074 | *0.010* |
| Ever drought | 0.003 | -0.005 | -0.008 | *0.103* | -0.021 | *0.099* | -0.011 | *0.010* |
| Length (months) lean season | 0.003 | -0.006 | -0.009 | *0.103* | -0.025 | *0.091* | -0.016 | *0.095* |
| log(population) commune | 0.042 | -0.075 | -0.117 | *0.103* | -0.111 | *0.092* | -0.124 | *0.095* |
| No. Fokontany in the commune | 0.078 | -0.140 | -0.218 | *0.094* | -0.181 | *0.087* | -0.166 | *0.091* |
| Rural areas | -0.042 | 0.077 | 0.120 | *0.099* | 0.075 | *0.090* | 0.060 | *0.095* |
| poverty rate (headcount) | -0.124 | 0.230 | 0.354 | *0.091* | 0.220 | *0.087* | 0.176 | *0.092* |