Early Childhood Stimulation, Micronutrient Supplementation and Child Development:

A Randomised Control Trial

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Background. It is by now very well established that the early years in child development are extremely important for outcomes in later life. Events and experiences in the early years have long run consequences and deficits accumulated early on are very difficult and costly to reverse in later life. There are many reasons for this. There is neurological evidence showing that crucial parts of the brain and its functions develop in the first two or three years of life. At the same time, it is by now clear that certain skills and attitudes acquired in the early years enable children to accumulate more effectively all types of skills.

There is evidence that well-targeted and well-designed interventions can have important impacts that are long lasting. Possibly, the most rigorous and well-known such intervention is the one designed and implemented in Jamaica by Sally Grantham-McGregor and colleagues. About 25 years ago a number of malnourished children living in Kingston, Jamaica were selected to participate in a study on the impact of nutrition and stimulation on child development. The children were aged between 9 and 24 months and were randomly assigned to four different groups. The first group was given a 'stimulation' intervention that consisted of weekly home visits by a community health aide who delivered a structured curriculum, designed by Grantham-McGregor and her colleagues, centred on improving the interaction between mother and child and included teaching basic concepts of space, quantity, position etc and other activities. The second group was given a nutritional supplement. A third group was provided with the stimulation and the nutrition supplement. Finally, a fourth group was kept as a control. The intervention lasted two years. All children involved in the study were observed at baseline (aged 9 to 18 months) and at the end of the study (aged 33 to 42 months), and then again at ages 7-8, 11-12, 17-18 and 23-24. The results were remarkable.

1. Both the nutrition intervention and the stimulation interventions improved significantly the cognitive development of the children, as measured at the end of the intervention. Indeed, children who received both treatments almost caught up with non-malnourished children living in the same neighbourhoods.
2. After a few years the impact of the nutrition intervention tapered away, whilst that of the stimulation intervention (on its own or in combination with the nutrition) was sustained. Stimulated children displayed better development than the control children in many dimensions. In particular, they showed higher performance in school.

3. 22 years after the intervention finished, the stimulated children had significantly better economic, cognitive, socio-emotional and educational outcomes.

The Jamaican intervention has since been replicated in a number of contexts, such as Bangladesh, and all of the ensuing evidence shows that a well-structured intervention in the early years can have large and long lasting impacts. The challenge faced by governments and policy makers is to identify interventions that achieve such impacts *at a reasonable cost and that are sustainable in the long run*. Although a standard cost benefit analysis of an intervention such as the Jamaican one would undoubtedly indicate that, in the long run it has high rates of return, in the short run it may be difficult to finance it, if its costs are excessive.

The present study. Given the above, our study has attempted to design an intervention that could be scaled up at reasonable cost, given the policy context and the resources (financial and human) available in Colombia, and to evaluate its impact.

The intervention. The intervention was targeted at children aged between 12 and 24 months at the start of the study, living in households that were beneficiaries of the program Familias en Acción. The study was conducted in 96 small municipalities (with between 5,000 and 50,000 inhabitants) in the following regions: (i) parts of Cundinamarca, Boyacá and Santander; (ii) parts of Antioquia, Risaralda and Caldas; (iii) Huila and Tolima. These choices were dictated both by the desire to focus on relatively small communities in a large enough geographical area (and hence representative of various realities) and our limited budget.

The intervention includes a stimulation and a micronutrient supplementation component. At the heart of the stimulation intervention is the interaction between mother and child. It involves weekly home visits during which the **home visitor** shows the **mother** a number of activities she can do with the child. Mothers are encouraged to participate in the play and to continue the activities throughout the following week. The home visitors follow a semi-structured **curriculum** that has a cognitive and language focus. The curriculum is organized on a week-by-week basis, with each week covering various age-appropriate activities - songs, nursery rhymes, books, puzzles, toys - lasting about one hour. The child is started on a particular week of the curriculum, with great attention paid to ensuring that children are started at the level appropriate to their stage of development rather than their age. The toys that are part of the curriculum are ones that can be made from locally available recycling material such as plastic bottles and materials scraps, and the home visitors show and encourage mothers to do so. In addition, didactic materials (booklets, picture books, puzzles) are part of the curriculum. These were designed and produced by the research team at relatively low cost. Some of the materials were rotated amongst children throughout the intervention; others (such as books) were given to the children. More generally, home visitors encourage mothers to converse, praise and play with the child during daily activities such as dressing, bathing and eating.

The micronutrient supplementation component consists of the provision of 'sprinkles', packaged in sachets that dissolve over food, and that have no taste, colour or odour. They provide iron, zinc, Vitamin A and Vitamin C in levels appropriate for children. The home visitors deliver the appropriate number of sachets to the home every two weeks and explain to/remind mothers how to administer them.

Whilst the intervention was based on the Jamaica study, it was adapted to the Colombian context in at least two important dimensions. First, the curriculum was changed so as to make it culturally appropriate for Colombia and, in particular, for the families targeted by the study. Second, we tried to identify local home visitors drawn from the communities themselves to deliver the curriculum. This reduces the costs considerably and may empower local communities to take ownership of the intervention itself, leading to beneficial spillovers.

Whilst the main emphasis of the curriculum remained on the interaction between mothers and children, the cultural adaptation ensured that the curriculum was suited to the Colombian context: for instance, books displayed local fruits and vegetables, and local housing. This adaptation was carried out in collaboration with Camila Fernández, a psychology Professor from the Universidad de los Andes, who has extensive experience in child development, and under the guidance of Sally Grantham-McGregor.

The second innovation of the present study is the adaptation to the reality of Colombian social policy. The challenge was the identification of a network of local women who could constitute the core of the intervention in that they could be hired, trained and could eventually take ownership of the intervention itself. We decided to work with one of the largest and most well-known social programs run by the Colombian Government: Familias en Acción (FeA), a conditional cash transfer program, targeted at the poorest 20% of households in the country. The beneficiaries of FeA receive cash payments if they comply with certain conditions, which involve taking young children to check-up visits in health centres and sending older children to school.

The beneficiaries of FeA elect periodically a representative, called the Madre Líder (ML). Each ML represents about fifty/sixty beneficiaries. This implies that, on average, there are about 5 or 6 children aged between 12 and 24 months amongst the beneficiaries of each ML. The MLs acquire a de facto leadership role in their communities. Moreover, it is often noticed that they are more entrepreneurial and have higher levels of education than other program beneficiaries. We therefore decided to target the MLs as possible 'home visitors'. In collaboration with the director of the program, in the 96 towns in the study, we identified the MLs and randomly selected three. Out of all children aged between 12 and 24 months living in FeA beneficiary households corresponding to each selected MLs, we randomly selected 5 to be enrolled in the intervention and included in the study. The intended sample of children, therefore, is made of 1440 (=96x3x5).

We presented the MLs with the hypothetical situation of what their role as a home visitor would involve and assessed their basic literacy skills with a short exam. If a ML was unwilling or unable to participate, or was deemed not suitable for the job, she a replacement for her was found (another ML or another woman in the community). However, her children remained part of the intervention and study sample. This was done so as to ensure the randomness of the sample. We recruited the available/suitable MLs (or other) to carry out the weekly visits and, where relevant, to distribute the micronutrient supplements. The process to recruit home visitors was identical in all 96 communities in the evaluation sample, so as to preserve the experimental design we describe below. We refer to the home visitors as "facilitadoras".

The evaluation. The study aimed at evaluating rigorously the impact of the intervention using an **experimental design**. For this reason, the 96 towns in the study were **randomly** allocated into four groups:

a. a control group
b. a stimulation group
c. a micronutrient supplementation group
d. a micronutrient supplementation and stimulation group

The evaluation started with a baseline data collection, which measured children's cognitive, motor and language development using the third version of the Bayley Scales of Infant Development, and a number of other indicators both at the household and at the individual level. In particular, we measured the extent of stimulation within the house (play activities and play materials) using the Family Care Indicator tool of UNICEF, maternal depression, and the time use of various family members. We also measured height, weight and haemoglobin of the children and their mothers. The socioeconomic questionnaire was extensive and designed to understand the mechanisms that might have been triggered by the program and that might have contributed to its effectiveness.

The intervention lasted a year and a half and was followed by another round of data collection on the same children. At follow up, we collected a variety of developmental indicators, including the Bayley test (for cognitive, language and motor development), the MacArthur Communicative Development Inventories (for vocabulary), the Bates Infant Characteristics Questionnaire (for temperament), and the Rothbart Infant Behaviour Questionnaires (using the subscales for attention focusing, inhibitory control and sociability amongst other socio-emotional traits). These data were again complemented by an extensive socio-economic questionnaire which included information on parental investments, time use and so on.

In addition to the survey data, we also collected data on the visits (each "facilitadora" completed a form at the end of each visit, indicating what had been done, materials used, etc.) and its quality (as assessed by the mentor of the home visitor during "supervision" which took place every couple of months). At the end of the intervention, we also had some focus groups discussions with some of the beneficiary mothers and semi-structured interviews with the "facilitadoras" to gain a better understanding of the intervention, its development and its potential impacts among beneficiaries and home visitors.

The randomised experimental design allows us to obtain rigorous and unbiased estimates of the impact of the stimulation and micronutrient supplementation interventions and of their interaction. The random allocation, which yielded a balanced sample, guarantees that the comparison between treatment and control children provides us with such estimates.

The implementation of the intervention (and of the evaluation). As mentioned above, the intervention was designed in such a way that it should be scalable at reasonable cost, given the existing infrastructure and human resources. The main components of the intervention were:

1. The development of the curriculum.
2. The training of professionals that could train the "facilitadoras" in the field.

3. The supervision of the "facilitadoras" throughout the intervention.

Six professionals were chosen among a number of applicants on the basis of their CV and an interview. They received training, over a month and a half, in child development, home visiting techniques and the curriculum. The training also included "practice" home visits. These professionals, who will be referred to as "mentors" "in what follows, then had the task to train the "facilitadoras" in the field – i.e. teach them the curriculum and the approach to home visiting – and mentor/supervise them throughout the intervention. To this end, each of them was assigned 8 towns, for a total of 24 "facilitadoras" each.

The training of the "facilitadoras" was split across two workshops. The first, lasting two weeks, covered the first part of the stimulation curriculum (activities for children ages 12 to 30 months) along with the fundaments of child development and the importance of stimulation, and toy construction workshops. Once this first round of training was completed, the "facilitadoras" were deemed ready to start the visits. This process took place at the same time as data collection (being careful in each village to ensure data collection had taken place before the intervention started), from February through June 2010, so by the end of June 2010 the intervention was fully phased-in across all treatment villages. The second phase of the training workshops took place between mid August and mid October 2010 over a one week period. In these sessions, the "facilitadora" and the "mentor" covered the second half of the curriculum (activities for children aged 30 to 42 months), revised lessons covered in the first workshop, resolved doubts, and discussed any outstanding issues.

After that, the six "mentors" became, for the rest of the intervention, mentors and supervisors of the "facilitadoras". They travelled around each of their 8 towns, spending up to a week in each, overseeing visits of their assigned "facilitadoras" and providing them with advice, training, feed-back, and support. This rotation scheme is such that each "facilitadora" can expect to have one week of interaction with her "mentor" once every 6 weeks, although in practice it was less often than this on average. Furthermore, "mentors" and "facilitadoras" are in touch on a regular basis: the "facilitadoras" receive weekly to fortnightly telephone calls to discuss progress and problems; they receive weekly text messages to reinforce key messages to be conveyed during home visits, and they receive monthly one-page bulletins that reinforce material covered during training sessions. Overall, the "mentors" have played a very important role in the intervention.

The funding of the study. The study, including the intervention and its evaluation, has been funded with research funds from a variety of institutions. We first received a large grant from the Economic and Social Sciences Research Council (ESRC) in the UK. This grant was then supplemented with one from the IADB, one from the World Bank and one from the International Growth Centre in the UK.

Results. We have started producing results from the study. The simple experimental design allows us, by a comparison of means, the estimation of the simple impacts of the intervention on a variety of outcomes. The wider aim of the project is to understand the mechanisms through which these impacts were obtained.

In this note, we report the impact on early childhood development, as measured by the Bayley Scales of Infant Development. In particular, we will report results on the cognitive scale, the

receptive language scale and the expressive language scale. In addition, we will also consider the impact of the program on the quality of the home environment, as measured by the Family Care Indicator. These latter impacts can hint at the mechanisms through which the intervention might be operating.

Throughout the analysis, we consider separately the impact of the three different interventions: the stimulation, the micronutrient supplementation and the combination of the two. Moreover, for the first three outcomes we consider separately the impact on children who started the program when they were less than 18 months and children that started above 18 months.

Before reporting the results, we want to point out two important facts. First, we used baseline data (collected before the start of the intervention) to check whether the randomization 'worked' – i.e. whether children living in towns assigned to different groups did not differ in a set of dimensions, including developmental levels, household wealth, quality of the home environment, and family background variables. A comprehensive analysis of baseline data showed no statistically significant differences across the four groups of towns in these variables.

The second preliminary exercise is useful to put the impacts we might find into context and to judge their size. In a complementary study, we studied the cognitive development of children aged 6 to 42 months living in the three poorest sectors of Bogota (each neighbourhood of the city is assigned by the Colombian Government to one of six strata that are used to price utilities)[1]. Within that sample, we constructed a wealth index based on household assets and dwelling characteristics and divided the children in groups corresponding to the quartiles of this index. In Figure 1, we plot the cognitive development of the children belonging to the first and fourth wealth quartiles, once the cognitive development index has been normalized using international standards (so that the reference population has an average index of 100 and a standard deviation of 15 for every age). In the same graph, we also plot, in red, the average development of the children in the pilot study living in 'control' towns (here we use both baseline and follow up data to cover a longer age interval).

Three important features that will be useful in interpreting our results emerge:

(i) All three groups represented in this graph exhibit increasing gaps relative to the reference population. While at 12 months these children do not exhibit any cognitive delays, by 30 months children in the lowest wealth quartile in Bogota and children in the pilot sample (living in FeA beneficiary families in semi-urban municipalities) have accumulated substantial delays.

(ii) There is a substantial difference between children in the first and fourth wealth quartile (within the sample of the poorest three sectors of Bogota). The difference by 30 months is about 0.4 of a standard deviation.

(iii) The children in our pilot study (small towns, semi-urban) exhibit development very similar to the children in the poorest quartile in Bogota.

[1] Originally, following the 1994 law of Public Services ("ley 142 de Servicios Públicos"), the Department for National Planning (DNP or *Departamento Nacional de Planeación*) was responsible for socio-economic stratification. Since 2004, this is responsibility of the Statistical Agency (DANE or *Departamento Administrativo Nacional de Estadística*).

Figure 1.
Cognitive development in Bogota and in control towns

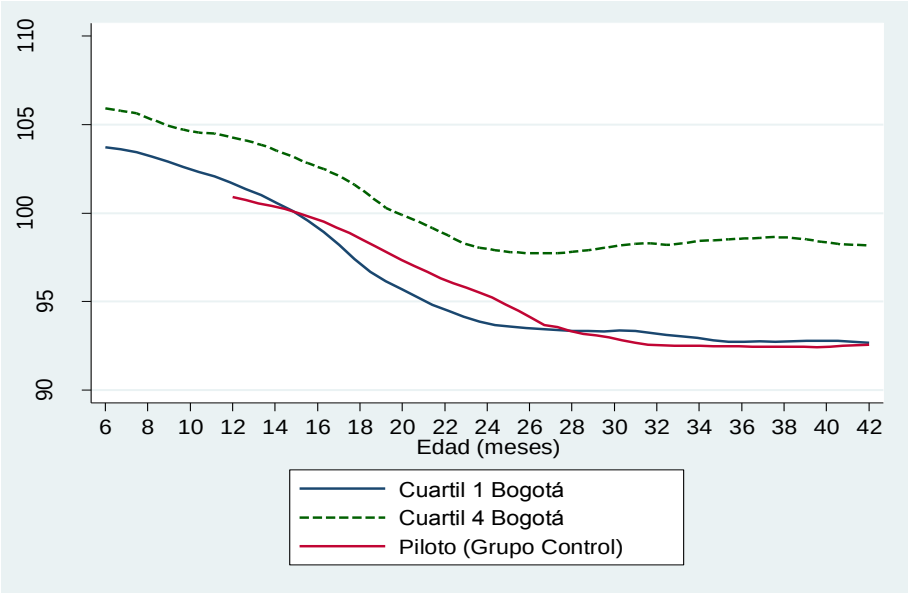

Table 1 reports the results on the cognitive scale of the Bayley Scales. We find that the average impact for children who received the stimulation intervention for 18 months, reported in the first row of the table, is equal to 0.26 standard deviations and is significantly different from zero. Moreover, if we differentiate children who started receiving the intervention at ages 12 - 18 months from those who were 19 - 24 months at the start of the intervention, we find that the impact is much larger in the latter group. In particular, we find that for the 'older' children the impact of the stimulation intervention is 0.37 standard deviations. The size of this latter effect is remarkable: if we compare this effect to the graphs in Figure 1, we see that this impact would be equivalent to moving a child from the bottom wealth quartile of the Bogotá sample to the top quartile (within the three poorest sectors). In other words, it would be equivalent to moving a child from a very poor family to a low-middle class family.

Rows 2 and 3 of Table 1 report the impacts of the other two interventions. Row 2 corresponds to the intervention that combines micronutrient supplementation and stimulation and Row 3 to micronutrient alone. Perhaps surprisingly, the impact of the intervention that combines micronutrient supplementation and stimulation are, as point estimates, smaller than those obtained by the stimulation only intervention. Moreover there is no apparent difference between the two age groups. One could think of a number of possible explanations (such as the micronutrient supplementation constituting some sort of crowding out of the stimulation), but it should be noted that the point estimates of the two impacts are not statistically different.

The results for the group that received only micronutrient supplementation are disappointing: on average the effect is small (0.06) and not significantly different from zero. For the younger group the effect is effectively zero, while for the older group is modest (0.13) but statistically different from zero.

Table 1 Impact (regresion coefficient and (SE)) of Interventions on Cognition			
	Age at Start of Intervention		
	All	12-18 months	19-24 months
Stimulation	0.261** (0.090)	0.161* (0.107)	0.369** (0.112)
Stimulation and Micronutrient Supplementation	0.211** (0.087)	0.220** (0.107)	0.219** (0.100)
Micronutrient Supplementation	0.053 (0.075)	-0.015 (0.087)	0.128** (0.091)

*significant at the 10% level; **significant at the 5% level

Table 2 Impact of Interventions on Receptive Language			
	Age at Start of Intervention		
	All	12-18 months	19-24 months
Stimulation	0.245** (0.094)	0.103 (0.098)	0.385** (0.128)
Stimulation and Micronutrient Supplementation	0.164** (0.088)	0.104 (0.110)	0.216* (0.115)
Micronutrient Supplementation	0.065 (0.096)	-0.138 (0.106)	0.239* (0.123)

*significant at the 10% level; **significant at the 5% level

In Table 2, we report the impacts of the interventions on receptive language. Once again we find large impacts for the stimulation intervention. And once again, the impact seems to be considerably larger for the older children, averaging at 0.385. For the group with combined interventions, the effect is smaller (at 0.16 for the whole sample) and, in this case, larger for the older children. Finally, the micronutrient supplementation intervention has zero impacts on average but positive for the older children (at 0.24).

Table 3 reports the impacts on expressive language. These are smaller than those on cognition or receptive language, which is not entirely surprising as expressive language is usually developed after receptive language. Stimulation is the only intervention group that had an overall significant benefit. Consistent with this hypothesis, we find that the effects are much larger for the older group of children. In this case, there are no large differences among the three groups.

Table 3
Impact of Interventions on Expressive Language

	Age at Start of Intervention		
	All	**12-18 months**	**19-24 months**
Stimulation	**0.130*** **(0.078)**	**-0.038** **(0.108)**	**0.278**** **(0.110)**
Stimulation and Micronutrient Supplementation	**0.093** **(0.092)**	**-0.075** **(0.116)**	**0.214*** **(0.110)**
Micronutrient Supplementation	**0.101** **(0.094)**	**-0.067** **(0.126)**	**0.233**** **(0.112)**

*significant at the 10% level; **significant at the 5% level

Finally, in Table 4, we report the impact of the interventions on the quality of the home environment, as measured by the Family Care Indicator described above. In particular, we report the average impacts of the three interventions on the total index and its three components. Notice that the two interventions that include stimulation have a significant impact on the total index. The impact is particularly sizeable on "Toys and Materials" and on "Activities" and – as one would expect - much smaller on "Adult Books and Magazines". Perhaps surprisingly, even the nutrition intervention has an impact on the total index, albeit much smaller. The effects on the sub-scales are not significantly different from zero for the nutrition intervention.

The evidence in Table 4 is especially interesting because it is suggestive of the channels through which the intervention might be affecting cognitive development and language.

Table 4 Quality of the Home Environment				
	Total Index	**Toys and materials**	**Activities**	**Books and Magazines**
Stimulation	**0.305** **(0.062)**	**0.948** **(0.172)**	**0.560** **(0.162)**	**0.128** **(0.103)**
Stimulation and Micronutrient Supplementation	**0.342** **(0.069)**	**0.747** **(0.202)**	**0.665** **(0.161)**	**0.324** **(0.111)**
Micronutrient Supplementation	**0.174** **(0.076)**	**0.403** **(0.227)**	**0.211** **(0.178)**	**0.244** **(0.118)**

*significant at the 10% level; **significant at the 5% level

Scaling up and further research. The impacts obtained in this pilot, given the resources used, are remarkable and probably call for the scaling up of this program. To us the intervention cost was about US$500 per child per year. However, it should be remembered that the largest fraction of the cost was in the supervision, which included both the supervisors' salaries and their per-diems for the travels around the towns. In our case, each "mentor" supervised only 3 home visitors per town (and 8 towns). This choice was determined by the sample size, geographical spread, and the resources available for the evaluation. At scale, it is easy to imagine that each "mentor" could supervise 10 to 12 home visitors per town and could be selected from nearby towns. This would reduce costs substantially. Our back of the envelope calculation is that the intervention could cost between US$300 and US$400 at scale.

Moreover, one could imagine splitting training from supervision, with the latter function performed by local officers (such as the Enlace Municipal), after suitable training. While this latter alternative might reduce the quality of the intervention and needs to be investigated, it could also reduce costs considerably.

However, in scaling up the intervention we need to factor in the costs of reaching more remote areas with less infrastructure and poorer human resources. Finally, it is important that such a program includes regular training and motivation of those delivering it so as to sustain the results in the longer run, beyond the initial enthusiasm that such innovations generate.