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Improving Infant Nutrition through the Market: Experimental Evidence in Ghana

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Improving Infant Nutrition through the Market: Experimental Evidence in Ghana*

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Abstract

We study the impact of introduction of a new complementary food product for infants into the market in Ghana. To investigate the effect of mother's purchase of the new product, Koko-plus, we conduct a sale experiment with randomly selected mother-infant pairs. We find that the introduction of Koko-plus into the market itself as well as mother's purchase of it significantly increase child's weight. The results imply that the complementary food market works for improving infant nutrition. However, the effect on body weight gain seems to be low and could be much higher because the number of packages purchased by the treated mothers is still small (less than 1 package per week on average). In order to obtain sufficient effects, interventions to encourage mothers' purchase will be required.

Key words — complementary food product, child nutrition, randomized controlled trial, Ghana

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1 Introduction

One of the most important development goals is the end of child undernutrition. The undernutrition during early childhood has adverse effects on health and socio-economic status in the long run (Bhaltra et al., 2017; Hoddinott et al., 2008; Hoynes et al., 2016; Malucchio et al., 2009). In developing countries, exclusive breast feeding until 6 months of age is recommended by WHO. After that, the introduction of complementary feeding is required because breastfeeding alone will result in nutritional deficiencies. However, since infants from 6 months to 2 years old have many restrictions on what they can eat, it is difficult to improve their nutrition through complementary feeding. Our study country, Ghana, seems to face typically this problem. Although stunting rate of children under 5 declined during recent 10 years in Ghana, 35% in 2003 to 19% in 2014 (GSS et al., 2014), the stunting rate tends to increase with the age, 8.0% at less than 6 months to 21.9% at 18-23 months old (GSS et al., 2015). This implies that there remains the problem of complementary feeding during infancy in Ghana.

A popular approach to tackle with this problem has been the use of nutritionally enhanced complementary or supplements, particularly through free distribution (Lutter, 2003). However, there are some concerns on the free distribution, such as sustainability of the aid and anchoring effects (Kremmer and Miguel, 2007; Fischer et al., 2019). The sale of commercial complementary food products, on the other hand, has now become a very common landscape even in developing countries. Most of them are also nutritionally enhanced[1]. Therefore, if such products prevail through the market and improve child nutrition, the "market-based approach" will be a sustainable way to solve the problem of infants' undernutrition.

There is a body of literature showing that the provision of nutritionally enhanced complementary foods has positive impacts on child nutrition[2]. However, since most of the studies are based on free distribution, little is known "if not free". The evidence for the positive effects of the products through free distribution does not necessarily mean that they have any impact if they are sold. If mothers buy less than receive the product free and its marginal effect is large, for example, we may obtain an insignificant effect of product sale even though we observe a significantly positive effect with free distribution. Economists made an effort to elicit willingness-

[1]Masters et al. (2016), however, point out that the quality variance of the commercial products is large in developing countries.

[2]See Dewey and Adu-Afarwuah (2008), which gives a good review on this topic in nutritional science.

to-pay for complementary food products to estimate their potential market size (Lybbert et al., 2018; Masters and Sanogo, 2002). However, their impact on child nutrition, if they are sold, is still unclear.

In this study, we investigate the impact of sale of a complementary food product on child nutrition in Ghana. To deal with the endogeneity problem relating to mothers' purchasing decision, we adopt a randomized controlled experiment, in which we give opportunities to buy a new complementary food product for infants, Koko-plus, to randomly selected mothers. We conduct the sale experiment every week and record exact number of packages purchased in each week to avoid unreliable retrospective recall data. We continue the weekly experiment for almost half a year. Then, we find that mother's purchase of Koko-plus significantly increases child's weight but that it has no effect on child's height.

By adopting a randomized controlled experiment, this study makes a new contribution to the literature on the role of the market for the improvement of child nutrition in developing countries, where all the existing studies reply on observational data (Abay and Hirvonen, 2017; Headey et al., 2019; Hirvonen and Hoddinott, 2017 ; Hirvonen et al., 2017 ; Hoddinott et al., 2015; Stifel and Minten, 2017). In addition, as far as we know, this is the first paper evaluating the impact of the introduction of a new complementary food product into the market based on a randomized controlled experiment because we conduct the sale experiment in areas where Koko-plus has not been introduced.

This study contributes to the literature on the effects of mothers' nutritional knowledge, as well. It has been a consensus that such knowledge improves child nutrition (Block, 2004, 2007; Glewwe, 1999) and educational intervention works well (Bhandari et al., 2004; Penny et al., 2005; Shi et al., 2010). However, a recent paper of Hirvonen et al. (2017) shows that maternal knowledge is actually important but how far depends on accessibility to the food market. To take account of this point in our study, we include educational intervention in the sale experiment and analyze how nutritional education to mothers affects the impact of product sales on child nutrition.

This paper consists of the following structure. First, we explain the detail of Koko-plus (Section 2). Then we describe the experimental design and data structure (Section 3). Section 4 presents the identification strategy and the results are provided in Section 5. Finally, we conclude in Section 6.

2 Backgrounds of Koko-plus

In 2015 a Japanese food company started to sell a new complementary food product for babies called "Koko-plus" in Ghana. The notable feature of this product is that this is a nutritionally enhanced food product made from soybeans but used as a sweet taste supplement to other foods, like a seasoning. By putting it, mothers can make any foods for babies rich in required nutrients for a child less than 24 months of age. Sales of complementary food products are common landscape in Ghana nowadays even in rural areas. However, most of those products are "dish type", that is, mothers feed their children with those products as a food. Or others are medical supplements, e.g. vitamin A, iron, and iodine, which are sold in pharmacies. Therefore, Koko-plus was the first supplementary food product commercialized in Ghana. With respect to the ingredient composition and nutrient content as well as the effect on child nutrition, refer to Ghosh et al. (2019). They show that Koko-plus will significantly improve child nutrition if sufficient amount is given to children based on randomized free distribution trial in Ghana.

The company began the sales of Koko-plus in and around Accra, the capital of Ghana in 2015. Then, in September 2016 they set a branch in Kumasi, the second largest city following Accra and the capital of Ashanti region, and started their business in Kumasi. Thus, as of January 2016 when we started our project in rural area in Ashanti region, this product was mainly sold in Accra and its surrounding area in Eastern region. During 2016 when we conducted our study, their business around Kumasi was very limited.

The market price of Koko-plus was 0.5 GHS.[3] This price seems sufficiently low, at least not so much expensive. For example, since one of the most popular dish type complementary foods was priced at around 1.2 GHS, the price of Koko-plus is lower than a half of this price. On other calculation, it is only 5% of the average household cash food expenditure per day in Ghana.[4]

3 Research Design and Data

3.1 Study Sites and Sampling Frame

We selected two districts in Ashanti region, Ahafo Ano South and Asante Akim South, as our study sites. The two districts are located on opposite sides of and 30 – 50 km away from Kumasi.

[3] GHS stands for Ghanaian Cedi, the currency in Ghana. 1 GHS = 0.253 USD in January 2016

[4] The average household cash expenditure on food and non-alcoholic beverages is 3,673 GHS per year (GSS, 2014), or 10.06 GHS per day. Thus, 0.5 GHS is about 4.97% of 10.06 GHS.

Both districts have a part of major highways, Kumasi-Sunyani Road and Accra-Kumasi Road respectively. There had been no Koko-plus sale until our research project started and during our study period our experiment was the only chance to buy Koko-plus. We selected 6 study locations in each district from communities that had a public health facility. Thus, we had 12 study locations in total. We can assume that accessibility to medical care was almost similar among the 12 study locations.

We conducted a census survey to make the list of baby-rearing mothers for sampling in each location from January to February 2016. Then, from the list we randomly selected mothers who has only one child less than 1 year old at the time of baseline survey and conducted a baseline survey of the households where the sample mothers belonged from March to May 2016. Note that we dropped mothers whose children were twins or more and mothers with siblings born within a year. It means that we ensure one-to-one pair between mother and child aged less than 1 year. We started the sale experiment of Koko-plus in September 2016 and continued for 6 months until February 2017. Finally, we conducted a follow-up survey from March to May 2017.

The baseline and follow-up surveys consist of two parts: Living Standard Survey (LSS) and Health and Nutrition Survey (HNS). LLS is a typical household survey. It collects data on household demography, agricultural production, other income sources, household expenditure, and asset holdings. HNS is designed to collect anthropometric and health data of targeted children. The sample size at the baseline is 351 households (i.e. 351 mother-child pairs) but we could follow up 229 households of them to the end of the study.

3.2 Experimental Design

We conducted the sale experiment of Koko-plus with and without educational component. There are three treatment arms: sale without education ("*Only Sale*" for short); sale with education ("*With Education*" for short); and control. The study locations were stratified and randomly assigned to one of the three arms: *Only Sale* (4 locations); *With Education* (4 locations); and control (4 locations).[5]

[5]We have only 12 locations as the units for randomization. Pooling all locations and assigning the treatment status to the pooled locations may raise biases because of the small number of the clusters. Thus, we used block randomization to minimize that concern in advance. We used the following variables collected in the demographic survey to create the strata: age of the mother, educational attainment of the mother, and household size.

In all the treatment arms, including the control, we conducted weekly interview during the 24 week study period. In the weekly interview we asked whether the child had any symptoms in the last seven days, and how and how many packages of Koko-plus the mother used only for treated groups. We measured the weight of the child every week and the height of the child three times during the study period: at the beginning, in the middle, and at the end. The weekly interviews were conducted by health workers who worked at the health center located in each study location. The reason why we also conducted weekly interview in control locations is that frequent visiting by the health workers or weekly weight measurement itself may affect parents' behaviors.[6] To minimize this concern, we conducted the interview and measurement with almost the same framing in both control and treatment groups.

In both *Only Sale* and *With Education* groups, we provided opportunities for mothers to buy Koko-plus. The sales were also conducted by the same health workers.[7] We started the sale experiment from the second week of September 2016 and continued for 24 weeks, almost for half a year. From the viewpoint of feasibility, the sale experiments were conducted at the health facilities where the weekly interviews were done. Only when the mothers did not come to the health facilities, the salespersons visited their houses and conducted the interview and sale.

We basically sold Koko-plus at the market price, 0.5 GHS. But every week we randomly selected mothers and offered a discount price: 40% discount (i.e. 0.3 GHS) for three mothers in each location and 20% discount (i.e. 0.4 GHS) for six mothers in each location. Since the random selection for discounting was done every week, mothers could not predict when they would be offered the discount price. We limited the maximum number of packages that a mother can buy in a week to 7 packages because one package per day was the recommended amount. By this restriction, we intended to avoid over-purchasing in a discounted week. Thus, we assume mothers generally used all the packages within the week when they purchased them.

Mothers in *With Education* group received educational intervention consisting of lecture and

[6]It is pointed out that frequent personal contacts of a health promoter have an influence on the adoption of health technologies. See Ritter et al. (2017).

[7]No one had known about Koko-plus before the intervention in our study sites because there had been no sale and our project introduced this product for the first time. Because of this, we were afraid that mothers might have a doubt or a concern about the quality and/or the effectiveness of the product and become reluctant to buy it. To minimize this stranger effect, we asked the health workers to sell the product to mothers. The health workers had been working at the local health facility before the intervention, and hence they were known to mothers well and were trusted by them.

practice session. They were called to educational meetings held three times per month at the health facility. In the first and third weeks of each month we had lectures on nutritional knowledge, where lecturers from Kwame-Nkrumah University of Science and Technology gave information about nutrition and good feeding practices. In the final week of each month we had practice sessions, where the lecturers demonstrated how to prepare good complementary foods for a baby by using locally available materials, e.g. egg, fish, and beans. As such, our educational intervention was not only informative but also practical. Note that the contents were very general and did not include any advertising messages about Koko-plus.

3.3 Data and Descriptive Statistics

We use data of child weight and height as variables indicating child nutrition. We convert the measurements into Z-scores, weight for age Z-score (WAZ) and height-for-age Z-score (HAZ), by following WHO's definition. We use the difference between initial Z-score value and final Z-score value as the outcome variable so that we evaluate the impact of the treatment in terms of child growth. The initial value is obtained from the data collected in the baseline survey and the final value is obtained from the follow-up survey.[8]

Table 1 presents summary statistics on child nutrition and household characteristics. The following three points are found salient in the table. First, the nutritional status of the sample children is bad at the baseline: the averages of WAZ and HAZ are -0.768 and -0.828. Second, the nutritional status becomes worse from the baseline to the follow-up: the means of the difference between the baseline and the follow-up are -0.177 for WAZ and -0.498 for HAZ. Third, this worsening trend is larger for HAZ than WAZ. This negative trend in child nutrition is not a peculiar case in our study, but common in Ghana as discussed in Introduction.[9] The total number of packages of Koko-plus purchased by a mother in the treatment groups is 21.1 on average during the 24 weeks of the sale experiment. This means that the mothers on average bought less than one package per week.[10]

[8]Some mothers were not available for the follow-up survey. In such cases, we use the measurements done during the final weekly interview instead. Since the follow-up survey was done shortly after the final weekly interview, we believe that the substitution does not cause any bias.

[9]See also GSS et al. (2015) Chapter 11.

[10]The purchase is not evenly distributed over the experimental period. Many mothers bought Koko-plus in the early stage of the experiment, but the number of mothers buying it declined over time. The details of the purchasing pattern and their analysis are found in Okonogi et al. (2020).

Table 2 presents baseline summary statistics for each treatment group and the results of balance check. Columns 1, 3, and 5 show means and standard deviations for each group: Control, *Only Sale*, and *With Education*. Columns 2, 4, and 6 show the number of observations. Columns 7, 8, and 9 show the p-values for t-test on difference in the sample means between the groups. There is no statistically significant difference in the baseline characteristics even at the 10% level. Therefore, we can say that our randomization worked well.

4 Identification Strategy

First, we estimate an intention to treatment (ITT) effect of the sale experiment and the educational intervention. The econometric model is as follows:

$$\Delta Y_{ijd} = \beta_1 T_j^{Sale} + \beta_2 T_j^{Edu} + \mathbf{X}_{ijd}\boldsymbol{\beta}_3 + \delta_d + \epsilon_{ijd} \quad (1)$$

where ΔY_{ijd} is the difference of outcome between the baseline and the follow-up for the child of household i in study location j of district d. As mentioned in Section 3, we use the weight-for-age Z-score (WAZ) and the height-for-age Z-score (HAZ) as the outcome of child nutrition. T_j^{Sales} is a dummy variable whose value is 1 if the household i lives in the treated location of the sale experiment and belongs to either *Only Sale* group or *With Education* group, otherwise 0. T_j^{Edu} is a dummy variable whose value is 1 if the household i belongs to *With Education* group otherwise 0. Therefore β_1 and β_2 are the difference-in-difference estimators and they can be interpreted as the ITT effect of the treatment. $\mathbf{X}_{ijd}$ is a vector of exogenous household characteristics at the time of the baseline survey, such as household size, age and education of household head and mother, gender and age of the child. It is included in the model to control for the effects of the difference in initial conditions. δ_d is an intercept by district. ϵ_{ijd} is an error term.

The ITT effect of the sale, β_1, can be interpreted as the impact of the emergence of the new complementary food product in the market, but it does not mean the impact of the use of the product itself. For the latter impact, we estimate a local average treatment effect (LATE) of the purchase of the product by using treatment status as an instrumental variable. The econometric specification is given as below:

$$\Delta Y_{ijd} = \gamma_1 Kokoplus_{ijd} + \gamma_2 T_j^{Edu} + \mathbf{X}_{ijd}\boldsymbol{\gamma}_3 + \delta_d + \epsilon_{ijd} \qquad (2)$$

where $Kokoplus_{ijd}$ is the total number of packages of Koko-plus purchased by household i in study location j of district d during the experiment period[11]. We use T_j^{Sales} as an instrument for $Kokoplus_{ijd}$. γ_1 indicates the LATE of Koko-plus purchase. γ_2 is the ITT effect of the educational intervention. The difference in the ITT effect of the nutrition education between β_2 in equation (1) and γ_2 in equation (2) is that the latter does not include an indirect effect of T_j^{Edu} through product purchase since it is captured by $Kokoplus_{ijd}$. As explained above, we gave information about how to prepare nutritious complementary foods by using locally available food materials to mothers in the nutrition education and it did not include any advertising messages about Koko-plus. Therefore, the mothers at least theoretically can improve complementary feeding without using Koko-plus. However, Okonogi et al. (2020) shows this educational intervention increases the purchase of Koko-plus packages as well. If Koko-plus has an impact on child nutrition, a part of the impact of educational intervention in equation (1) is from Koko-plus use. Such an indirect effect is separated in equation (2) because T_j^{Edu} is also included in the model of the first stage. Therefore γ_2 can be interpreted as the ITT effect of the nutrition education other than Koko-plus consumption.

5 Results

Table 3 is the estimation results of equation (1) showing the ITT effect of the intervention. Columns 1 and 2 show the results when we use the difference of WAZ as the dependent variable and columns 3 and 4 show the results with the difference of HAZ as the dependent variable. The results in columns 2 and 4 include the exogenous household characteristics at the baseline, $\mathbf{X}_{ijd}$, to control for the initial condition. The coefficient for the sale experiment in column 2 is positive and statistically significant at 10% level when we control for the observable household heterogeneity, although it is not significant without controlling for the initial condition as shown in column 1. This suggests that the introduction of the new complementary food product into the

[11] We use the number of packages "purchased" rather than "consumed". We admit that "consumed" is ideal, but it is very hard to obtain reliable data as to "actual" amount consumed through interviews. Moreover, we cannot observe whether the mothers resell Koko-plus or not. In such a situation, it is most likely that the number of packages actually consumed is equal or less than the number of packages purchased. Therefore, if Koko-plus consumption has a positive impact on child nutrition, the estimated γ_1 is biased to downward and can be interpreted as the lower bound of the impact of Koko-plus consumption.

market increases child's weight. In contrast to the significant effect on child's weight, there is no significant effect of the sale experiment on child's height regardless of including the household characteristic variables as shown in columns 3 and 4. As for the nutrition education, neither child's weight nor height is influenced by it significantly as shown in Table 3. This non-significant result of the nutrition education is consistent with Bhandari et al. (2004), who show nutrition education through trained health workers improves parental feeding practices but there is no significant impact on physical growth of children. Following their findings, our nutrition education may also change mothers' feeding practices. Unfortunately, however, we did not collect data about feeding practices.

The results of the first stage estimation for equation (2) are given in Table 3. Because sample size is not the same for WAZ and HAZ due to missing height measurements, we show the estimation result for each case. The two results are very similar and the treatment variable, T_j^{Sales}, is found to work well as an instrument.

Table 5 shows the local average treatment effect (LATE) of mother's purchase of Koko-plus on child growth. Column 1 gives the result for WAZ and column 2 is that for HAZ. The coefficient for total number of packages of Koko-plus purchased is positive and statistically significant at the 5% level in the case of WAZ, but it is not significant in the case of HAZ. This result suggests that Koko-plus consumption increases child's weight but may not affect child's height.

The estimated impact of Koko-plus on WAZ is 0.012 per package purchased, which means that the average change in WAZ will be 0.252 per 21 packages per 24 weeks since average number purchased within the treatment groups is 21 packages as shown in Table 1. This much effect seems to be low as it is only one quarter of standard deviation. However, considering that no change in WAZ or HAZ indicates that the growth of weight or height is following the trend of global standard, the positive effect on WAZ, even if it is small, is a sign of improving. But we do not mean that the improvement is large enough. Although we do not have any criteria to determine how much improvement is sufficient in general, we think that if WAZ becomes close to 0 or the global mean, it will be good enough. To achieve that much gain in WAZ, a simple conjecture suggests that a child should be given at least 3 packages of Koko-plus per week: the change in WAZ must be three times larger than the current estimate, i.e. 0.252 x 3 = 0.756, because average WAZ at the baseline is -0,768.

6 Conclusions

In this study, we evaluate the impact of the introduction of a new nutritionally enhanced complementary food product, Koko-plus, into the market on child growth in Ghana. There is growing literature examining the role of the market for the improvement of child nutrition. However, since most of the existing studies rely on observational data, randomized controlled experiment is required to identify the causal impacts. Our study precisely does it to fill the knowledge gap. Our randomized controlled experiment is a weekly sale experiment of Koko-plus that lasts for 24 weeks. By using the treatment status as an instrumental variable, we estimate the local average treatment effects of mother's purchase of Koko-plus on child nutrition, and find it increases child's weight significantly but not child's height. We conduct educational intervention to mothers at the same time. But we do not observe any significant effect of the nutrition education on child's physical growth.

Our result provides the evidence that the market does work for the improvement of child nutrition in a rigorous way for the first time. However, the average effect on WAZ we estimate is not so large and there is a room to increase the effect size. We consider that this small impact is due to the insufficient amount of purchase of Koko-plus: less than 1 package per week. Therefore, further work is required to investigate how to encourage mothers to buy the product more under various constraints. One of the most typical constraints is budget. But our other work, Okonogi et al. (2020), suggests that the budget is not restricting so much in our case. Or a subsidy policy may induce purchasing behavior in the long run (Dupas, 2014). Nutrition education to mothers is also considered as one of the promising policies to induce mothers' purchase. In fact, Okonogi et al. (2020) show that the nutrition education increases the number of Koko-plus packages that mothers buy on average. Similar results are shown by Bhandari et al. (2004). In the present study, however, there is no evidence of direct impact of the educational intervention on child's physical growth.

We have some limitations in the analysis. First, we use purchased amount rather than consumed amount. The amount purchased by mothers cannot always be the same as the amount consumed by children. But since we can reasonably assume that actual amount consumed must be less than the amount purchased, we consider that our positive and statistically significant estimation indicates at least the lower bound of the impact of Koko-plus consumption. Second, the attrition is relatively large. It was difficult to stop dropping out from our experiment because having interviews with anthropometric measurements every week and/or attending educational sessions are tedious for some mothers. We include exogenous household characteristics in the model to control for it, but sample selection bias may still remain.

References

Abey, K., and Hirvonen, K. (2017). Does market access mitigate the impact of seasonality on child growth? Panel data evidence from northern Ethiopia. *The Journal of Development Studies*, 53(9), 1414-1429.

Bhalotra, S., Karlsson, M., and Nilsson, T. (2017). Infant health and longevity: Evidence from a historical intervention in Sweden. *Journal of the European Economic Association*, 15, 1101-1157.

Bhandari, N., Mazumder, S., Bahl, R., Martines, J., Black, R. E., Bhan, M. K., and other members of the Infant Feeding Study Group. (2004). An educational intervention to promote appropriate complementary feeding practices and physical growth in infants and young children in rural Haryana, India. *The Journal of Nutrition*, 134(9), 2342-2348.

Block, A. S. (2004). Maternal nutrition knowledge and the demand for micronutrient-rich foods: Evidence from Indonesia. *The Journal of Development Studies*, 40(6), 82-105.

Block, A. S. (2007). Maternal nutrition knowledge versus schooling as determinants of child micronutrient status. *Oxford Economic Papers*, 59, 330-353.

Dewey, K. G., and Adu-Afarwuah, S. (2008). Systematic review of the efficacy and effectiveness of complementary feeding interventions in developing countries. *Maternal and Child Nutrition*, 4(s1), 24-85.

Dupas, P. (2014). Short-run subsidy and long-run adoption of new health products: Evidence from a field experiment. *Econometrica*, 82(1), 197-228.

Fischer, G., Karlan, D., McConnell, M., and Raffler, P. (2019). Short-term subsidies and seller type: A health products experiment in Uganda. *Journal of Development Economics*, 137, 110-124.

Ghana Statistical Office (GSS). (2014). *Ghana living standards survey round 6 (GLSS 6) Main report*. Accessed February 2020, available at https://www.statsghana.gov.gh/gssmain/fileUpload/Living%20conditions/GLSS6_Main%20Report.pdf

Ghana Statistical Office (GSS), Ghana Health Service (GHS), and ICF International. (2015). *Ghana Demographic and Health Survey 2014*. Rockville, Maryland, USA: GSS, GHS, and ICF International. Accessed March 2020, available at https://dhsprogram.com/pubs/pdf/FR307/FR307.pdf

Ghosh, S. A., Strutt, N. R., Otoo, G. E., Suri, D. J., Ankrah, J., Johnson, T., Nsiah, P., Furuta, C., Murakami, H., Perera, G., Chui, K., Bomfeh, K., Amonoo-Kuofi, H., Tano-Debrah, K., and Uauy, R. (2019). A macro- and micronutrient-fortified complementary food supplement reduced acute infection, improved haemoglobin and showed a dose-response effect in improving linear growth: a 12-month cluster randomised trial. *Journal of Nutritional Science*, 8, e22.

Glewwe, P. (1999). Why does mother's schooling raise child health in developing countries? Evidence from Morocco. *Journal of Human Resources*, 34(1), 124-159.

Heady, D., Hirvonen, K., Hoddinott, J., and Stifel, D. (2019). Rural food market and child nutrition. *The American Journal of Agricultural Economics*, 101(5), 1311-1327.

Hirvonen, K., and Hoddinott, J. (2017). Agricultural production and children's diets: Evidence from rural Ethiopia. *Agricultural Economics*, 48, 469-480.

Hirvonen, K., Hoddinott, J., Minten, B., and Stifel, D. (2017). Children's diets, nutrition knowledge, and access to markets. *World Development*, 95, 303-315.

Hoddinott, J., Heady, D., and Dereje, M. (2015). Cows, missing milk markets, and nutrition in rural Ethiopia. *The Journal of Development Studies*, 51(8), 958-975.

Hoddinott, J., Maluccio, A. J., Behrman, J. R., Rafael, F., and Martorell, R. (2008). Effect of a nutrition intervention during early childhood on economic productivity in Guatemalan adults. *The Lancet*, 371, 411-416.

Hoynes, H., Schanzenbach, D. W., and Almond, D. (2016). Long-run impacts of childhood access to the safety net. *American Economic Review*. 106, 903-934.

Krener, M., and Miguel, E. (2007). The illusion of sustainability. *The Quarterly Journal of Economics*, 122, 1007-1065.

Lutter, C. K. (2003). Macrolevel approaches to improve the availability of complementary foods. *Food and Nutrition Bulletin*. 24, 83-103.

Lybbert, T. J., Stephen, A. V., Adams, K. P., and Guissou, R. (2018). Household demand persistence for child micronutrient supplementation. *Journal of Health Economics*, 62, 147-164.

Maluccio, J. A., Hoddinott, J., Behrman, J. R., Martorell, R., Quisumbing, A. R., and Stein, A. D.

(2009). The impact of improving nutrition during early childhood on education among Guatemalan adults. *The Economic Journal*, 119, 734-763.

Masters, W. A., and Sanogo, D. (2002). Welfare gains from quality certification of infant foods: Results from a market experiment in Mali. *The American Journal of Agricultural Economics*, 84, 974-989.

Masters, W. A., Nene, M. D., and Bell, W. (2016). Nutrient composition of premixed and packaged complementary foods for sale in low- and middle-income countries: Lack of standards threatens infant growth. *Maternal and Child Nutrition*, 13(4), e12421.

Okonogi, S., Sakurai, T. and Annan, R. (2020). The effects of nutrition education on demand persistence for the complementary food product in Ghana. mimeo.

Penny, M. E., Creed-Kanashiro, H. M., Robert, R. C., Narro, M. R., Caulfield, L. E., and Black, R. E. (2005). Effectiveness of an educational intervention delivered through the health services to improve nutrition in young children: A cluster-randomized controlled trial. *The Lancet*, 365, 1863-1872.

Ritter, M., Camille, E., Velcine, C., Guillaume, R. K., and Lantagne, D. (2017). Optimizing household chlorination marketing strategies: A randomized controlled trial on the effect of price and promotion on adoption in Haiti. *The American Journal of Tropical Medicine and Hygiene*, 97(1), 271-280.

Shi, L., Zhang, J., Wang, Y., Caulfield, L. E., and Guyer, B. (2009). Effectiveness of an educational intervention on complementary feeding practices and growth in rural China: A cluster randomized controlled trial. *Public Health Nutrition*, 13(4), 556-565.

Stifel, D., and Minten, B. (2017). Market access, welfare, and nutrition: Evidence from Ethiopia. *World Development*, 90, 229-241.

Table 1. Summary statistics of whole sample

	Mean	Std. Dev.	N
Child nutrition			
WAZ at the baseline	-0.768	1.275	271
WAZ at the follow-up	-0.945	1.114	271
Difference in WAZ	-0.177	1.125	271
HAZ at the baseline	-0.828	1.413	245
HAZ at the follow-up	-1.326	1.277	245
Difference in HAZ	-0.498	1.387	245
Household and child characteristics			
Total number of Koko-plus packages purchased during the experiment†	21.1	22.4	197
Child age in month at the baseline	7.9	3.2	288
Gender of the child (Girl = 1)	0.545	0.499	288
Age of mother at the baseline	28.1	7.0	288
Number of years in school of mother	6.8	3.5	288
Age of household head at the baseline	42.8	14.7	288
Number of years in school of household head	7.2	4.4	288
Household size at the baseline	6.4	3.2	288

Notes : WAZ means weight-for-age Z-socre. HAZ means heght-for-age Z-score.
†In the control group, the total purchased amount of Koko-plus is 0 for all households. Therefore we only show the value among the treatment groups (*Only Sale* and *With Education*).

Table 2. Baseline summary statistics by treatment groups and balance check

Treatment groups	Control (C)		*Only Sale* (T1)		*With Education* (T2)				
	Mean (Std. Dev.)	N	Mean (Std. Dev.)	N	Mean (Std. Dev.)	N	*p*-Value H0: C = T1	*p*-Value H0: C = T2	*p*-Value H0: T1 = T2
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
WAZ at the baseline	-0.726	84	-0.705	91	-0.866	96	0.918	0.456	0.381
	(1.343)		(1.348)		(1.144)				
HAZ at the baseline	-0.785	75	-0.694	80	-0.982	90	0.697	0.339	0.204
	(1.309)		(1.586)		(1.331)				
Child age in month at the baseline	7.6	91	7.6	96	8.3	101	0.998	0.129	0.107
	(3.3)		(3.1)		(3.2)				
Gender of the child (Girl = 1)	0.549	91	0.573	96	0.515	101	0.748	0.634	0.416
	(0.500)		(0.497)		(0.502)				
Age of mother at the baseline	27.8	91	28.6	96	28.0	101	0.428	0.856	0.501
	(7.6)		(6.7)		(6.7)				
Number of years in school of mother	6.7	91	6.9	96	6.8	101	0.691	0.848	0.838
	(3.5)		(3.5)		(3.7)				
Age of household head at the baseline	42.3	91	43.2	96	42.8	101	0.687	0.801	0.870
	(15.5)		(14.3)		(14.3)				
Number of years in school of household head	7.5	91	6.8	96	7.4	101	0.293	0.838	0.383
	(4.4)		(4.3)		(4.4)				
Household size at the baseline	6.5	91	6.5	96	6.3	101	0.921	0.664	0.586
	(3.3)		(3.4)		(2.8)				

Table 3. The ITT effect of the sale and nutrition education on child growth

Dependent variable	Δ WAZ		Δ HAZ	
	(1)	(2)	(3)	(4)
Sale experiment: T^{sale}	0.210	0.205 *	0.008	0.018
	(0.143)	(0.108)	(0.237)	(0.227)
Nutrition education: T^{edu}	-0.118	-0.199	0.307	0.241
	(0.139)	(0.138)	(0.300)	(0.286)
Household characteristics: $\mathbf{X}_{ijd}$	No	Yes	No	Yes
Observations	271	271	245	245
R^2	0.006	0.142	0.014	0.073

Notes : Standard errors clustered at the study location level in parentheses.
*** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$. WAZ means weight-for-age Z-socre. HAZ means heght-for-age Z-score.

Table 4. First stage regression results for the LATE estimation model

Dependent Variable: Number of Koko-plus packages purchased	First Stage for WAZ (1)	First Stage for HAZ (2)
Sale experiment: T^{sale}	16.53 ***	16.67 ***
	(3.239)	(3.040)
Nutrition education: T^{edu}	8.636	8.698
	(9.084)	(9.378)
Household characteristics: $\mathbf{X}_{ijd}$		
Age of child	-0.354	-0.370
	(0.348)	(0.367)
Gender of the child (Girl = 1)	-0.724	-1.198
	(2.069)	(2.572)
Age of mother	0.164	0.168
	(0.107)	(0.126)
Number of years in school of mother	0.038	-0.121
	(0.500)	(0.498)
Age of head	0.047	0.061
	(0.076)	(0.056)
Number of years in school of household head	0.311	0.528 *
	(0.246)	(0.301)
Household size	0.011	0.198
	(0.425)	(0.521)
R^2	0.224	0.231
F	52.74	95.48
p-Value	0.000 ***	0.000 ***
Observations	271	245

Notes : Standard errors clustered at the study location level in parentheses.
*** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$. WAZ means weight-for-age Z-socre.
HAZ means heght-for-age Z-score.

Table 5. The LATE of Koko-plus purchase on child growth

Dependent variable	ΔWAZ	ΔHAZ
	(1)	(2)
Number of Koko-plus packages purchased: $Kokoplus_{ijd}$	0.012 **	0.001
	(0.006)	(0.013)
Nutrition education: T^{edu}	-0.306	0.231
	(0.220)	(0.318)
Household characteristics: $\mathbf{X}_{ijd}$	Yes	Yes
F	52.74	95.48
p-Value	0.000 ***	0.000 ***
Observations	271	245

Notes : Standard errors clustered at the study location level in parentheses.
*** $P < 0.01$, ** $P < 0.05$, * $P < 0.1$. WAZ means weight-for-age Z-socre. HAZ means heght-for-age Z-score.