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CHILD MALNUTRITION, CONSUMPTION GROWTH, MATERNAL CARE AND PRICE SHOCKS: NEW EVIDENCE FROM NORTHERN GHANA

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Abstract: Childhood malnutrition remains a significant global health concern. In order to implement effective policies to address the issue, it is crucial to first understand the mechanisms underlying malnutrition. This paper uses a unique dataset from Northern Ghana to explain the underlying causes of childhood malnutrition. It adopts an empirical framework to model inputs in the production of health and nutrition, as a function of child, household and community characteristics. The findings suggest that child characteristics are important in explaining inputs and nutritional outcomes, and that maternal agency and health contribute to improved health status. Household resources in the form of consumption are positively associated with food intake and nutritional outcomes. Simulations show that income growth, improving maternal care and avoiding sudden price shocks have a positive but rather limited effect on the reduction of malnutrition. Effects are greater in children under two. Hence, policies that address underlying determinants simultaneously, and target the youngest population of children, could have the largest effect on reducing malnutrition in this population.

Key words: nutrition, health, Ghana, policy simulations, input demand

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1. INTRODUCTION

It is estimated that about 45% of deaths of children under five are linked to malnutrition (Black et al., 2008). In addition, more than 160 million children under age five suffer from stunting, or being too short for their age, with the highest rate of stunting worldwide being found in sub-Saharan Africa (SSA) (UNICEF, 2013). Stunting results from prolonged periods of malnutrition and exposure to infectious diseases and evidence shows that more than 70% of stunting takes place before a child's second birthday (Leroy et al., 2014).

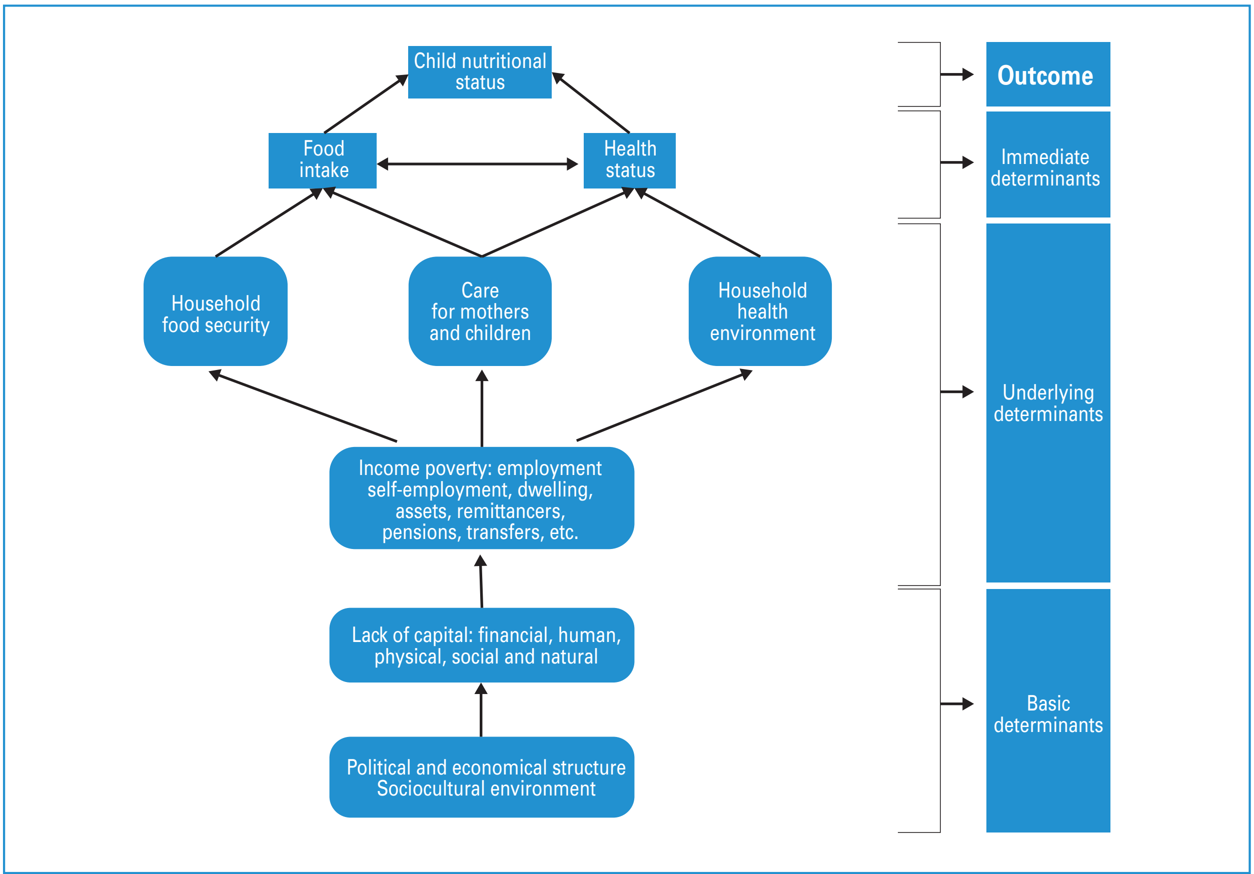
It is widely recognized that children all over the world have the same growth potential in early childhood, given the right conditions, such as adequate feeding and low exposure to infectious diseases (WHO Multicentre Growth Reference Study Group and Onis, 2006). Growth deficits are therefore a strong indicator of overall standards of living and well-being. These early life deficits in turn can lead to deficits in later life outcomes, which perpetuates a cycle of under-achievement and low standards of living. For example, stunting in early childhood has been linked to impaired cognitive development, reduced school achievement, lower economic productivity in adulthood and poorer maternal reproductive outcomes (Dewey and Begum, 2011). Consequently, the effects of malnutrition place a significant burden on the global and regional economy and contribute to so-called 'poverty traps' (Crosby et al., 2013, World Bank, 2006).

In Ghana, chronic malnutrition remains a significant public health issue. Nearly 19% of children under five are stunted, according to the latest available data (GSS, GHS & ICF International, 2015). Levels of stunting are higher for children in rural areas, with mothers with low levels of educational achievement, or living in poor households. The Northern region – one of the regions studied in this paper – shows the highest prevalence of stunting; with a rate of 33%. However, there has been a steady decrease in stunting at the national level from 38% in 2003 to 28% in 2008, to the current level of 19%, in 2014.

In order to implement effective policies to address malnutrition, it is first important to understand the immediate and underlying determinants of malnutrition. These determinants have been studied extensively in a large variety of settings. A widely recognized framework, depicted in Figure 1 (page 7), identifies food intake and health status as the two immediate determinants of nutritional status (Black et al., 2008). These immediate determinants are, in turn, caused by household food security, care for mothers and children and a healthy household environment - all of which are underlying determinants. Poverty is driving these underlying determinants, while at the national level, basic determinants include the socio-political context and availability of resources (physical, financial, human, social and natural).

Previous research has concentrated on understanding the two immediate determinants of malnutrition: food intake and health status. A systematic review of interventions concluded that feeding interventions, such as promotion of complementary feeding through nutritional education and zinc supplementation, had the highest potential to reduce stunting around the globe. With 99% coverage, such programmes would reduce the global prevalence of stunting for children up to 36 months by 15% and 17% respectively (Bhutta et al., 2008). In combination with several other interventions, including micronutrient interventions and disease control interventions, there is the potential to decrease stunting by one-third (Bhutta et al., 2008). A more recent update of these estimations, using a scale-up of ten interventions to 90% coverage, estimated a 20% reduction in stunting (Bhutta et al., 2013). While this shows large potential, these results also indicate that the majority of stunting would not be eliminated, by focusing solely on these immediate determinants. Hence, although the evidence is limited, there is a need to further examine how focused interventions on the underlying determinants of malnutrition – namely, food security, care for mothers and children and a healthy household environment – can reduce child malnutrition. A recent review of nutrition-sensitive interventions focused on agriculture, social protection, early childhood development and education, as possible mechanisms to improve nutritional outcomes. However, this review suggests that the evidence base is limited. Such interventions require more specific nutrition goals and actions to unleash their full potential in combating child malnutrition (Ruel et al., 2013).

Figure 1 – ***Framework of the immediate and underlying causes of child malnutrition***



Source: Adapted from Black et al. (2008)

To further understand the potential role of public policy in eliminating malnutrition, this paper studies the factors associated with childhood malnutrition, focusing on its underlying determinants, by operationalizing the framework in Figure 1, in a child health production function. It also simulates several interventions to improve the underlying determinants, in order to estimate their potential role in reducing malnutrition. Using a unique dataset from Ghana, we model the underlying determinants in several input demand functions, to understand what drives demand for input in the child health production function. We also estimate the conditional demand for nutritional status, in a similar framework.

This paper makes a number of important contributions to the existing literature on child nutrition and public policy.

First, many studies focus on one element of the underlying determinants of child nutrition in the framework of Figure 1, such as diet diversity (Arimond and Ruel, 2004), maternal education (Chen and Li, 2009, Glewwe, 1999, Handa, 1999), income growth (Haddad et al., 2003) or water and sanitation (Checkley et al., 2004, van der Hoek et al., 2002). By estimating the framework as one complete model – albeit in two stages – we are able to quantify the underlying mechanisms determining inputs, and the likely pathways contributing to nutritional status.

Second, our data is unique in as far as it captures a particularly vulnerable population, namely rural poor households with pregnant women or very young infants. Other studies usually depend on national level household data, such as Demographic and Health Surveys, which limits the possibility of studying such a particular group in detail.

Third, using our full model, we can show the potential and effect size of various interventions and provide suggestions for effective public action.

The paper proceeds as follows:
Section 2 describes the data and methods employed;
Section 3 presents findings on the immediate and underlying determinants associated with improved child nutrition;
Section 4 simulates several policy interventions to enhance child nutrition;
Section 5 discusses the implications of the findings; and
Section 6 draws conclusions.

2. DATA AND METHODS

Data for this study are derived from the baseline survey of the Livelihood Empowerment Against Poverty (LEAP) 1000 impact evaluation. LEAP 1000 is a cash transfer programme targeted at extremely poor households with pregnant women and mothers with children under 12 months, in the Northern and Upper East Regions of Ghana. The programme is an extension of Ghana's flagship poverty alleviation programme LEAP, which reaches more than 213,000 households across the country (November 2016). It is implemented by the Department of Social Welfare (DSW) as at the Ministry of Gender, Children and Social Protection (MoGCSP). Selection into the programme relies on a proxy means test (PMT), with a sharp cut-off established by the MoGCSP.

The LEAP 1000 impact evaluation is a longitudinal, mixed-method study implemented by a consortium of research partners including: the UNICEF Office of Research – Innocenti; the University of North Carolina at Chapel Hill; the Institute of Statistical, Social and Economic Research at the University of Ghana; and the Navrongo Health Research Center. Quantitative and qualitative baseline data was collected between July and September 2015 from 2,497 households in five districts in the Northern and Upper East Regions of Ghana, and 20 households were interviewed as part of the qualitative study.

For the purpose of the impact evaluation, the quantitative sample consists of households that are close to either side of the eligibility threshold for the programme. The evaluation strategy exploits this 'discontinuity' in eligibility at the threshold and uses households immediately above the threshold (who are therefore not eligible) as a comparison group for households just below the threshold (who are eligible for the programme). This paper uses baseline data only; none of the households below the cut-off had received the transfer from the cash transfer programme. Moreover, a comprehensive analysis of baseline characteristics showed that the groups of households above and below the threshold are similar.[1]

Due to its demographic targeting (i.e. households with pregnant women and mothers with children under 12 months), the data for the impact evaluation include many children under five, as well as household and mother-level measures. This makes this data unique for studying the underlying determinants of nutrition, in a particularly vulnerable population. For instance, the programme was successful in targeting the poorest of the poor, as more than 90% of individuals were living below the national poverty line (UNICEF OoR, ISSER, UNC-CH & NHRC, 2016).

2.1 Econometric model

It is typical to operationalize the framework of Figure 1 in a health production function. The rationale is that the human body is a biological system that 'produces' health using a set of inputs such as food intake and (lack of) illness (i.e. the immediate determinants in Figure 1). Such a production function is useful to identify which inputs are particularly important in the production of health. The demand for inputs in the production function are usually modelled in a separate specification,

[1] For more details on the study design and baseline analysis, see the baseline report (UNICEF OoR, ISSER, UNC-CH & NHRC, 2016).

with the important note that the inputs are endogenous (Behrman and Deolalikar, 1988). Consider a sick child, who may be fed more food and receive medicine to overcome the illness. In this case, the inputs are partly determined by the health status; the model may therefore suffer from simultaneity bias. One way to circumvent the problem of endogeneity is to find strong instruments for the inputs in the production function. Typically, the prices of different foods, the availability of health care or the quality of health care, are used. Should adequately rich longitudinal data be available, the complete history of inputs can be used (Puentes et al., 2016). However, most datasets are not sufficiently rich to allow for the estimation of the full production function, and ours is, unfortunately, no exception.[2] The next best estimation in this case, is the reduced form child health function, based on the underlying model of the utility-maximizing family (Becker, 1981, Behrman and Deolalikar, 1988). In fact, we estimate two types of reduced form equations: the input demand function, and the conditional nutrition demand function.

2.2 Underlying determinants of child nutrition and explanatory variables in the model

In these models, the outcome (demand for health inputs or nutrition, h_i) is a function of child characteristics (x_i), parental characteristics (x_p), household indicators (x_h) and community features (x_c); all of which are considered exogenous:

$$h_i = h(x_i, x_p, x_h, x_c, \mu) \quad (1)$$

Child characteristics include age, sex, birth outcomes, and number of siblings. Household characteristics consist of indicators such as maternal characteristics, household size and head of family characteristics. Community features consist of indicators such as the distance to the nearest health centre, nearest market, water and sanitation facilities, and the prices of common food and non-food items. Finally, μ is an error term for unobserved child, household and community heterogeneity, affecting the child's nutritional status. The error term is assumed to be uncorrelated with the x variables in this model. We cluster standard errors at the community level. What follows is a detailed description of the explanatory variables of the underlying determinants of child nutrition included in the models. The means and standard deviations of the key variables used in this study, are presented in Table 1 (page 13).

2.3 Child characteristics

The survey collected detailed information for each of the main female respondent's children aged under five. We restrict the sample to children aged 6 - 59 months, for several reasons. First, it is recommended that children under 6 months are breastfed exclusively; this limits the number of feeding variables we can include in our models. Second, measurement errors in terms of height are generally larger for children under 6 months, due to the difficulty of accurately measuring infants. Third, stunting often starts to become a problem when infants are transitioning from breastfeeding to complementary feeding, at 6 months. This is due to the low quality of the complementary food

[2] Previous drafts of this paper attempted to identify and use instruments to estimate the full production function, but several sets of instruments (prices, distance to health facilities, non-self community means of inputs) were found too weak in predicting the inputs in the demand equation.

replacing breastmilk, which in combination with lack of hygiene in food preparation, and potential exposure to unsafe drinking water, causing infections, together inhibit growth (Shrimpton et al., 2001). We further restrict our sample to children for whom we have full information on all relevant indicators and to children who live in communities in which five or more children could be sampled.[3] Our final analysis sample consists of 2,460 children, with full information on all indicators for the input demand functions, 2,460 children for the height-for- age z-scores (HAZ) conditional demand function and 2,435 children for the weight-for-age z-scores (WAZ) conditional demand function. On average, children in the sample are 26.6 months old, with an even split between boys and girls. Four percent of the sample is a twin. Birth order and preceding birth interval are included in the analysis, as these indicators are common predictors of nutritional status (Jayachandran and Pande, 2013, Rutstein, 2005). We take the gender of the child's siblings to account, for potential intra-household preferences. For example, if there are strong preferences to invest in boys, and the child is a girl with two male siblings, we may expect worse outcomes for the female child. The children in the sample have, on average, one male and one female sibling.

2.4 Parental characteristics

We include a number of parental characteristics, particularly for the mother of the child. Educational achievement of mothers is low, with more than 80% never having received any formal schooling. Nutrition and health knowledge was constructed based on the mother's responses to six questions on child nutrition and health.[4] The correct number of responses was summed and the average number of correct responses was higher than four. Parental health, usually proxied by height, could be an important determinant of child health, given the potential of the genetic endowment passed on to offspring. Unfortunately, our data does not include parental height; we therefore use a measure of self-reported subjective health, giving five response options (poor, fair, good, very good and excellent), which has been found to be a good predictor of future mortality and morbidity (DeSalvo et al., 2006). We dichotomize this indicator into self-reported good, very good or excellent health. Just over three-quarters (76%) of mothers reported good, very good or excellent health. Agency – measuring decision-making power of the mother in the household – is an aggregate score based on six statements.[5] The agency score was cut into terciles; 36% of mothers scored in the lower tercile, 40% in the middle tercile, while the remaining 24% had an agency score in the top tercile. In terms of household decision-making, respondents in the qualitative study indicated that it was usually the elders and the males in the household who decided how to spend income. In some cases, the respondent herself also had a say in decisions, especially when related to her own children.

[3] This is due to the calculation of community means for certain variables, further details below.

[4] Questions related to the importance of exclusive breastfeeding, immediate breastfeeding after birth, duration of breastfeeding, foods rich in iron, foods rich in vitamin A and knowledge about home treatment of diarrhea.

[5] Agency is measured on 5-point Likert scale, with the following six statements: Your life is determined by your own actions; You have the power to make important decisions that change the course of your own life; You have the power to make important decisions that change the well-being of your children; You have the power to make important decisions that change the well-being of your household; You are capable of protecting your own interests within your household; You are capable of protecting your own interests outside of your household (e.g. in the community, in groups in which you participate). Internal consistency among the statements is high, with Cronbach's alpha of 0.77.

2.5 Household characteristics

In terms of household characteristics, the mean household size is nearly seven members and the share of women in reproductive age is 23%. This second indicator aims to capture the idea that the larger the share of women in the household – assuming women care more for children's health than men – may lead to higher demand for inputs, and as a consequence, better nutritional status. Furthermore, less than 10% of households are headed by a woman, and 80% of heads of households never went to school. The mean monthly consumption expenditure per adult equivalent is approximately 92 Ghana cedi (GH₵), which translates roughly into US$ 0.74 per adult equivalent per day.[6] We have included the natural log of this expenditure measure in our analysis.

2.6 Community characteristics

Community characteristics consider whether the household has access to improved sanitation facilities, improved sources of drinking water and appropriate hand washing facilities. The dwelling floor type, there presence of bed nets, and vaccination coverage, are also considered.[7] Water and sanitation facilities are included due to their important effect on infectious diseases, and as a consequence nutritional status (Dangour et al., 2013, Spears, 2013). Floor type is included, since dirt floors increasingly expose children to parasites and therefore diarrhoea, compared to other floor types such as cement (Cattaneo et al., 2009). Bed nets are included as they have shown to be highly effective against childhood morbidity, especially malaria (Lengeler, 2004). Vaccinations have an important role in preventing common childhood diseases. For each of these indicators, we calculate the non-self community mean[8], in order to make them exogenous, as it is likely that these indicators are correlated with other household characteristics (Christiaensen and Alderman, 2004, Kabubo-Mariara et al., 2009). Indicators show that about 60% of children live in communities with access to an improved source of water, while only 10% have access to improved sanitation facilities. Appropriate hand washing facilities is even lower at 7%. One-quarter of the houses in these communities has a mud floor. Two-thirds sleep under a bed net. Vaccination coverage is 75%.

In addition to the household survey, baseline data was collected from all markets and health facilities close to the communities under study. GPS coordinates were taken from each household and at locations of health facilities, which allows us to calculate the distance to health services. 'Health facilities' comprise a village health post, a community-based health planning service (CHPS) or a health centre. Since health centres provide more comprehensive care, we include the distance to the nearest health centre for each household, as a measure of access to health services.
The average distance to the nearest health centre is about 10 km (not shown). To account for the long tail in the distribution of distances, we include the natural log of the distance to the nearest health centre. Unfortunately, there is no information available on the quality of the closest health care centre, which is arguably also an important determinant for health and nutrition status (Lavy et al., 1996). The prices of seven common consumption items at the nearest market are matched to the household data.

[6] Exchange rate at 15 September 2015: GH₵ 1 = US$ 0.2448337399.

[7] Definitions of improved water and sanitation facilities are based on standard classifications according to WHO and UNICEF (2016).

[8] The non-self community mean is the mean value of the indicator, averaged over all observations in the community, excluding the value of the indicator for the household itself

Table 1 – ***Variables used in study (N=2,460)***

Variable	Mean	SD	Min	Max
Child characteristics				
Age in months	26.60	16.81	6	59
Female	0.50	0.50	0	1
Twin	0.04	0.19	0	1
Birth order	3.23	1.80	1	11
Birth interval				
First birth	0.18	0.39	0	1
< 24 months	0.10	0.30	0	1
24 – 35 months	0.21	0.41	0	1
36 – 47 months	0.22	0.41	0	1
48 months or more	0.29	0.45	0	1
Number of male siblings	1.22	1.15	0	7
Number of female siblings	1.12	1.05	0	6
Parental characteristics				
Age of mother	29.73	6.30	15	49
Education of mother				
No schooling	0.81	0.39	0	1
Some primary	0.08	0.27	0	1
Primary completed or higher	0.11	0.31	0	1
Nutrition & health knowledge (0 – 6, with higher values meaning more knowledgeable)	4.35	1.24	0	6
Self-reported health good/very good/excellent	0.76	0.43	0	1
Agency score				
Low	0.36	0.48	0	1
Medium	0.40	0.49	0	1
High	0.24	0.43	0	1
Father present in household	0.87	0.33	0	1
Household characteristics				
Household size	6.86	2.64	2	27
Share of women 12-49 in household	0.23	0.09	0.07	0.67
Age of head of household	39.10	12.28	18	102
Female headed household	0.08	0.28	0	1
Head of household no formal schooling	0.80	0.40	0	1
Log of monthly household consumption per adult equivalent	4.35	0.63	1.14	6.54
Community characteristics				
Non-self mean of improved source of water	0.58	0.33	0	1
Non-self mean of improved source of sanitation	0.10	0.17	0	1
Non-self mean of floor type (1 if mud floor)	0.25	0.24	0	1
Non-self mean of sleeping under bed net yesterday	0.67	0.19	0	1
Non-self mean of vaccination coverage	0.75	0.26	0	1
Non-self mean of appropriate hand washing facilities	0.07	0.11	0	1
Log of distance to nearest health centre	8.74	1.16	0.61	10.61
Price of Guinea corn/sorghum (Ghana Cedi)	0.77	0.29	0.45	1.33
Price of maize (Ghana Cedi)	0.85	0.34	0.43	1.59
Price of millet (Ghana Cedi)	0.79	0.40	0.33	2.17
Price of rice (local) (Ghana Cedi)	1.47	0.67	0.89	2.80
Price of dried fish (Ghana Cedi)	10.37	4.30	2.00	20.00
Price of okro (Ghana Cedi)	4.38	2.27	2.22	10.83
Price of petrol (Ghana Cedi)	3.94	0.33	2.99	4.75

2.7 Inputs in the health production function: Food intake and health status

We use the quantitative and qualitative data to provide an accurate description of the nutritional and health situation of the children in the sample. We also compare the figures to those from the most recent Demographic and Health Survey, conducted in 2014 (Table 2).

Table 2 – ***Inputs and nutritional outcomes (N=2,460)***

Variable	Mean	SD	Min	Max	GDHS[1]
Inputs: Health status					
No diarrhoea in last two weeks	0.58	0.49	0	1	0.87
No other illness in last two weeks	0.70	0.46	0	1	0.82
Inputs: Food intake					
Consumed iron-rich food yesterday	0.68	0.47	0	1	0.38[2]
Consumed grains, roots and tubers yesterday	0.80	0.40	0	1	0.69[2]
Consumed dairy products yesterday	0.21	0.41	0	1	0.07[2]
Consumed vitamin A-rich fruits and vegetables yesterday	0.70	0.46	0	1	0.30[2]
Consumed other fruits and vegetables yesterday	0.11	0.31	0	1	0.08[2]
Consumed three or more meals yesterday	0.45	0.50	0	1	0.43[3]
Exclusively breastfed for first 6 months	0.62	0.48	0	1	n/a
Nutritional outcomes					
HAZ score	-1.28	1.68	-5.92	5.91	-1.49
Stunted (HAZ <- 2)	0.31	0.46	0	1	0.33
Severely stunted (HAZ< -3)	0.13	0.34	0	1	0.11
WAZ score[4]	-1.09	1.18	-4.95	3.8	-1.13
Underweight (WAZ < -2)[4]	0.20	0.40	0	1	0.19
Severely underweight (WAZ < -3)[4]	0.06	0.24	0	1	0.04

Note: [1] Ghana Demographic and Health Survey 2014, children from Northern and Upper East region, N= 590
[2] Youngest child under five in the household, N= 363
[3] Youngest child under two in the household, N= 210
[4] For WAZ, N= 2,435

Health status is based on the incidence of diseases in the two weeks prior to the survey. Diarrhoea is a common disease in many low-income countries and Ghana is no exception. It is estimated that every episode of diarrhoea increases the odds of stunting by 4% (Bhutta et al., 2008). We combine the incidence of fever and symptoms of acute respiratory infections (ARI) into a single indicator of non-diarrhoeal illness. To ease interpretation of results, all indicators are coded so that a higher score indicates a more positive outcome (i.e. lack of illness). About 58% of the children had not suffered from diarrhoea, indicating that 42% did experience the disease in the two weeks before the survey. This is much higher than the regional average based on the DHS sample. In addition, 30% experienced fever or symptoms of ARI, which is also much higher than the findings in the most recent DHS. Health problems in young children were also a salient theme in the qualitative study; many mothers interviewed talked about how their children suffered symptoms such as 'high temperature', 'cough', 'headache', 'stomach pain' and 'convulsions'. In the qualitative interviews, the mothers indicated that in case of sickness, their first response generally was to use traditional herbs or buy medication from a local seller, followed up by a visit to a health facility, if there was no improvement in the condition. Lack of resources to pay for health care or lack of health insurance appeared to be the biggest barrier to seeking immediate health care for sick children.

Food intake of a single child is notoriously difficult to measure in large-scale field surveys. In order to know the exact quantity and quality of food intake, each spoonful of food the child ate would have to be weighed, just before it entered their mouth. Since this practice is not feasible for most studies, we proxy the *quality* of food intake by looking at the different food groups proposed by WHO (WHO, 2010) - all based on 24 hours recall of the main caregiver of the child: consumption of iron-rich foods; consumption of grains, roots and tubers; consumption of dairy products; consumption of vitamin A -rich fruits and vegetables; and consumption of other fruits and vegetables. The quality of a child's diet has been linked to nutritional status in many settings (Arimond and Ruel, 2004). To assess the *quantity* of food intake, we used meal frequency (whether the child had 3 meals or more). Meal frequency has been found to be a strong predictor of energy intake in infants and young children and thus an important input in the production of health (Working Group on Infant and Young Child Feeding Indicators, 2006). In addition, an indicator on whether the child was breastfed exclusively for the first six months of life, was included. This was measured by the response to the question: "At what age (months) did you first give (name of child) water or other fluids, besides breast milk?" Exclusive breastfeeding and breastfeeding in general has been proven to reduce the incidence of illnesses and therefore contributes to optimal growth and weight gain (UNICEF, 2012).

About two-thirds of children consumed iron-rich food (e.g. (organ) meat, fish or iron-fortified foods); 80% consumed grains, roots or tubers; 21% consumed dairy products; and 70% consumed vitamin A-rich plant foods (e.g. yellow flesh fruits and vegetables or dark green leafy vegetables). All of these numbers are considerably higher than for comparable children in the DHS.[9] Less than half of the children received the recommended three or more meals per day and about 62% was exclusively breastfed for the first 6 months.

Findings from the qualitative work indicate that households live on a very monotonous diet with Tuo Zafi (TZ) - a thick porridge made from maize or millet flour - being the main cereal staple, generally accompanied by a soup with *okro*, groundnuts, *bito*, or similar local plants. Small children are fed *koko* - a porridge made with fermented corn. Rice is also a preferred staple, but is more expensive than maize and millet (see Table 1). Whenever possible, households prefer to eat more beans as they believe 'they are good for your blood'.

[9] While this may seem strange, results for iron-rich foods are driven by intake of fish (in the qualitative interviews, women often spoke about *Amani*; dried fish). Vitamin A-rich foods are driven by 'green leafy vegetables', which is usually cassava leaves in Northern Ghana; a cheap and common vegetable. Note that the DHS was fielded from September – December, i.e. during a different season than the LEAP survey. The higher consumption of cassava leaves could be due to this seasonality.

2.8 Nutritional outcomes: Height-for-age and weight-for-age

We are interested to document the effects of the underlying and immediate determinants on long-term measures of child malnutrition. The appropriate nutritional measure is therefore height-for-age z-scores (HAZ), which has been commonly used as an indicator of overall long-term health and human capital (Victora et al., 2008). Weight, on the other hand, is more often used as a short-term indicator of undernutrition, since weight responds more quickly to deviations in food intake and infection. Nevertheless, we consider weight-for-age as a nutritional outcome, which can reflect both short-term and long-term malnutrition.[10]

In terms of outcomes, the mean HAZ score is -1.28 (SD 1.68), indicating that the average child in the sample is 1.28 standard deviations (SD) below the median of a healthy reference population. More than 30% of children are stunted (HAZ < -2 SD) and 13% are severely stunted. The average WAZ-score is similarly low, with 20% of the children in our sample being underweight. The rate of severe underweight is 6%. While the mean HAZ score is lower in the DHS sample, the rates of stunting and severe stunting in our sample are in line with the regional averages in Northern Ghana. The WAZ score, and the rates of underweight and severe underweight, are also comparable to the DHS sample (Table 2).

[10] We do not consider weight-for-height due to our interest in measuring long-term effects, rather than short-term deviations in weight.

3. RESULTS

This section presents results of the estimation of equation (1), first on the immediate determinants of child malnutrition - namely food intake and health status (input demand) - and then on the nutritional outcome, HAZ and WAZ (conditional demand). We also test for the joint significance of child, parental, household and community characteristics respectively in each estimation separately.

3.1 Immediate determinants of child malnutrition: food intake and health status (input demand)

The results for the nine input demand functions are presented in Table 3 (pages 18-21). The models are estimated with a probit model, and marginal effects are presented. We present estimations for the full sample of children aged 6-59 months, but also for the subsamples of children aged 6-23 and 24-59 months, as it is likely that these different age groups have different nutritional and health needs. The results for these sub-groups are reported in Appendix Tables A-2 and A-3. The highlights are discussed below.

Age is an important factor for the input indicators. Compared to the youngest cohort (6-11 months), children in the older age groups are less likely to have had an episode of diarrhoea, are less likely to have been breastfed exclusively during the first 6 months of their lives, but are more likely than the younger children to have eaten most of the food groups, with the exception of dairy products.[11] There are no significant differences between boys and girls and children of multiple births are more likely to have eaten iron-rich foods and vitamin A-rich fruit and vegetables. Number of siblings has a positive association with the likelihood of exclusive breastfeeding, but a negative association with two of the food groups: grains, roots and tubers; and other fruits and vegetables; suggesting some competition for resources within the household.

Parental characteristics have only a limited correlation with the demand for inputs. For example, maternal education is only significant in two cases: higher maternal education is (weakly) associated with better health status and exclusive breastfeeding. The mother's age is positively related to the lack of diarrhoea, the lack of other illnesses, and the consumption of iron-rich and vitamin A-rich foods, although the size of the associations are small. In other words, each additional year of mother's age is associated with less than one percentage point increase in the probability of these inputs. The presence of the father in the household is not correlated with any of the inputs. The mother's agency has some interesting and puzzling results. While higher agency is strongly associated with better health outcomes and exclusive breastfeeding, it has a negative association with the demand for dairy products and appropriate meal frequency. Maternal self-reported health status is positively related to both child health indicators, but has no association with the food inputs. Surprisingly, nutritional knowledge has mostly no effect on any of the inputs, except for a small and weakly significant association with the intake of dairy products. Parental characteristics are jointly significant (at the 10% level) in six of the nine input demand equations: both health indicators, exclusive breastfeeding, the intake of dairy products, and vitamin A-rich fruit and vegetables, and appropriate meal frequency.

[11] We also experimented with including a continuous measure of age in months, in combination with age in months squared and age in months cubed. Results from these specifications are highly similar and available upon request.

Table 3 – ***Marginal effects from probit models on health and nutrition inputs in children aged between 6 and 59 months***

	(1) No diarrhea in last 2 weeks	(2) No other illness in last 2 weeks	(3) Exclusive breastfeeding before 6 months	(4) Iron-rich food	(5) Grains, roots and tubers	(6) Dairy products	(7) Vitamin-A rich fruits and vegetables	(8) Other fruits and vegetables	(9) Meal frequency (at least 3 per day)
Child characteristics									
Age group (ref = 6 - 11 months)									
12-17 months	0.020	-0.038	-0.034	0.163***	0.159***	0.044*	0.270***	0.040**	0.081***
	0.031	0.028	0.021	0.024	0.027	0.026	0.028	0.016	0.029
18-23 months	-0.045	-0.027	-0.094**	0.122**	0.213***	0.074	0.343***	0.101**	0.223***
	0.050	0.042	0.046	0.053	0.038	0.051	0.044	0.042	0.063
24-35 months	0.117***	-0.044	-0.372***	0.286***	0.231***	-0.326***	0.436***	0.076***	0.247***
	0.040	0.039	0.038	0.033	0.034	0.024	0.030	0.024	0.041
36-47 months	0.143***	-0.008	-0.367***	0.251***	0.256***	-0.316***	0.440***	0.108***	0.299***
	0.041	0.027	0.035	0.034	0.031	0.021	0.029	0.019	0.030
48-59 months	0.196***	0.023	-0.397***	0.219***	0.272***	-0.300***	0.459***	0.123***	0.310***
	0.034	0.030	0.039	0.035	0.030	0.025	0.027	0.024	0.040
Sex of child (1 = female)	0.001	0.023	0.015	-0.022	0.005	0.004	-0.023	0.002	-0.002
	0.020	0.017	0.020	0.022	0.017	0.014	0.017	0.012	0.018
Child is a twin	-0.051	0.081	0.136**	0.190***	0.071	-0.038	0.198**	0.027	-0.030
	0.066	0.073	0.069	0.061	0.053	0.039	0.077	0.042	0.070
Birth order number	-0.018	-0.005	-0.053***	0.005	0.029**	0.005	-0.000	0.018**	0.001
	0.015	0.014	0.014	0.015	0.013	0.011	0.012	0.008	0.013
Number of male siblings in the household	0.010	-0.000	0.055***	-0.010	-0.052***	-0.011	-0.011	-0.020*	0.018
	0.016	0.016	0.017	0.018	0.014	0.011	0.018	0.010	0.016
Number of female siblings in the household	0.017	0.013	0.055***	-0.016	-0.044***	-0.010	-0.022	-0.018*	0.021
	0.019	0.016	0.015	0.017	0.014	0.013	0.015	0.010	0.015

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Table 3 – Marginal effects from probit models on health and nutrition inputs in children aged between 6 and 59 months

	(1) No diarrhea in last 2 weeks	(2) No other illness in last 2 weeks	(3) Exclusive breastfeeding before 6 months	(4) Iron-rich food	(5) Grains, roots and tubers	(6) Dairy products	(7) Vitamin-A rich fruits and vegetables	(8) Other fruits and vegetables	(9) Meal frequency (at least 3 per day)
Parental characteristics									
Mother's education (ref = none)									
Some primary	-0.067	-0.015	0.088**	0.023	-0.028	-0.023	-0.007	0.012	0.036
	0.042	0.042	0.038	0.036	0.036	0.024	0.038	0.027	0.035
Primary completed or above	0.018	0.054*	0.010	0.039	0.015	0.012	-0.034	0.024	0.009
	0.037	0.032	0.034	0.029	0.027	0.025	0.035	0.022	0.034
Mother's age	0.007***	0.005*	0.003	0.005*	0.004	0.001	0.005**	-0.001	-0.001
	0.003	0.003	0.003	0.003	0.003	0.002	0.002	0.002	0.003
Living with father	-0.072	-0.069	0.002	0.036	-0.071	-0.040	-0.048	-0.028	-0.035
	0.054	0.044	0.055	0.048	0.046	0.034	0.040	0.028	0.044
Mother's agency (ref = Low)									
Medium	0.119***	-0.006	0.070**	-0.020	0.022	-0.040**	0.028	-0.024	-0.056**
	0.033	0.025	0.030	0.029	0.025	0.017	0.025	0.030	0.026
High	0.147***	-0.001	0.135***	-0.038	0.016	-0.046***	-0.010	-0.031	-0.094***
	0.036	0.027	0.031	0.030	0.029	0.017	0.023	0.029	0.029
Nutritional knowledge	-0.008	0.009	0.008	0.007	0.011	0.010*	-0.008	-0.001	-0.013
	0.009	0.009	0.010	0.009	0.009	0.006	0.010	0.006	0.009
Self-reported health good/very good/excellent	0.156***	0.147***	-0.007	0.034	-0.005	-0.013	0.019	0.004	-0.009
	0.021	0.026	0.024	0.027	0.022	0.018	0.024	0.017	0.025
Household characteristics									
Log of AE household consumption	-0.068***	-0.075***	0.034*	0.035*	0.020	0.016	0.033*	0.042***	0.078***
	0.019	0.019	0.020	0.021	0.020	0.015	0.019	0.012	0.017

Table 3 – Marginal effects from probit models on health and nutrition inputs in children aged between 6 and 59 months

	(1) No diarrhea in last 2 weeks	(2) No other illness in last 2 weeks	(3) Exclusive breastfeeding before 6 months	(4) Iron-rich food	(5) Grains, roots and tubers	(6) Dairy products	(7) Vitamin-A rich fruits and vegetables	(8) Other fruits and vegetables	(9) Meal frequency (at least 3 per day)
Community characteristics									
Vaccination coverage[1]	0.034	-0.093							
	0.072	0.066							
Improved sanitation[1]	-0.032	-0.167**							
	0.074	0.073							
Improved source of water[1]	0.051	0.064							
	0.049	0.042							
Appropriate handwashing facilities[1]	0.027	0.249*							
	0.120	0.137							
Mud floor[1]	-0.097	0.090							
	0.077	0.062							
Slept under bed net[1]	0.131*	0.023							
	0.078	0.076							
Distance to nearest health centre	0.022*	-0.031***	-0.015	0.038**	-0.013	0.006	-0.002	-0.032***	0.023
	0.013	0.012	0.013	0.017	0.012	0.008	0.010	0.008	0.014
Price of Guinea corn/sorghum			-0.130	0.503**	0.117	-0.159	0.067	0.019	-0.125
			0.207	0.209	0.183	0.109	0.167	0.136	0.194
Price of maize			0.048	-0.051	-0.132	0.049	-0.161	-0.160	0.216
			0.172	0.166	0.154	0.088	0.153	0.105	0.147
Price of millet			0.041	-0.120*	-0.147*	-0.016	-0.098*	0.043	0.052
			0.085	0.063	0.085	0.036	0.054	0.048	0.062
Price of rice (local)			0.024	-0.141*	0.244***	0.068*	0.109	0.011	-0.108
			0.073	0.082	0.077	0.038	0.081	0.048	0.082
Price of dried fish			0.009**	-0.007	0.002	-0.005*	-0.008**	0.003	-0.003
			0.004	0.005	0.004	0.003	0.003	0.004	0.004
Price of okro			0.011	0.022	-0.044***	0.001	-0.020	-0.000	0.016
			0.014	0.018	0.013	0.008	0.015	0.010	0.015
Price of petrol			-0.108**	0.005	0.003	-0.043	-0.110**	0.135***	-0.110*
			0.055	0.063	0.059	0.028	0.045	0.043	0.056
Observations	2460	2460	2460	2460	2460	2460	2460	2460	2460

Table 3 – Marginal effects from probit models on health and nutrition inputs in children aged between 6 and 59 months

	(1) No diarrhea in last 2 weeks	(2) No other illness in last 2 weeks	(3) Exclusive breastfeeding before 6 months	(4) Iron-rich food	(5) Grains, roots and tubers	(6) Dairy products	(7) Vitamin-A rich fruits and vegetables	(8) Other fruits and vegetables	(9) Meal frequency (at least 3 per day)
Tests for joint significance (p-value):									
Child characteristics	0.000	0.402	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Parental characteristics	0.000	0.000	0.000	0.240	0.169	0.039	0.095	0.872	0.054
Household characteristics[2]	0.000	0.000	0.007	0.082	0.148	0.154	0.010	0.000	0.000
Community characteristics	0.069	0.006	0.001	0.000	0.022	0.131	0.000	0.000	0.011

Notes: Cluster-robust standard errors in second row. Additional control variables not reported: birth interval, household size, share of women aged 12- 49, age of head of household, sex of head of household and whether she/he ever went to school.

* p<0.10

** p<0.05

*** p<0.01.

[1] Non-self community mean.

[2] Includes household size, share of women aged 12 – 49, age of head of household, sex of head of household, and whether she/he ever went to school.

Household consumption has positive associations with five of the food inputs. However, it has strongly negative effects on the health status, which seems counter-intuitive, i.e. higher welfare is associated with poorer health outcomes. The magnitude of the associations are relatively small though. For example, a 10% increase in household consumption is associated with a 0.0068 (0.68 percentage points) and 0.0075 (0.75 percentage points) increase in the probability of diarrhoea and non-diarrhoeal disease, respectively. Nonetheless, in order to validate these results, we perform checks with two alternative datasets, the Ghana Living Standards Survey (GLSS) 2012/2013, and the DHS 2014. Looking at the relation between household consumption (GLSS) or wealth (DHS) and incidence of illness for children under five, we also observe a negative association in these datasets, at least for the lowest two quintiles, which, arguably, is where most of our households are located (see Appendix).

One potential explanation for this relation is survival bias. This occurs when child mortality in the poorest households is higher than in the richer households, and only healthier and stronger children survive in the poorest households. In the Ghana DHS, all forms of child mortality are indeed higher in the lowest quintile, compared to the other quintiles (GSS, GHS and ICF International, 2015). We can also look at this potential explanation in our data by assessing the relation between household consumption and whether a child ever died in the household (Figure A-2 in the Appendix). In our data, we also observe a negative relation between child mortality and household consumption. However, the effect is not statistically significant.

Another potential explanation is the employment status of the mother of the child. If a mother works, she may have less time to care for her child, resulting in increased risk of illness notwithstanding higher household income. This association was, for example, found in rural Ethiopia (Sinmegn Mihrete et al., 2014). Our data includes a module on each household member's time use, which includes questions on how many hours was spent doing casual work and formal work, in the seven days prior to the survey. We construct an indicator equal to one if the mother of the child spent at least one hour performing casual or formal work outside the home. We then include this indicator in the input demand regression for health inputs. The results (not shown but available upon request) indicate that the mothers' employment status is, indeed, negatively associated with both health indicators. This means that children of women who work are more prone to illness. However, the coefficient on consumption decreases only by a few decimal points in both equations, remaining strongly significant. Hence, this association cannot fully explain why we observe the negative relation between household consumption and health status.

A third and final potential explanation is that poorer households simply underreport episodes of illness because they are unable to recognize illness, or because they forget. For example, a study in India showed that recall bias for morbidity was higher among poorer households, especially when recall periods were longer. The authors hypothesize that this is due to the normalization of illness in the household. In other words, members of poor households are so often sick that they tend to forget when exactly an illness occurred, or may not feel it is worth mentioning to an interviewer (Das et al., 2012). Another study to validate the accuracy of child morbidity data in the DHS concluded that, *"[the] inverse relationship between reported child morbidity and social deprivation is likely to be* *the result of recall and reporting biases, where less educated, poorer mothers tend to report child illness less commonly than richer mothers"* (Manesh et al., 2008: p. 197). There is unfortunately no possibility of validating this explanation in our data, as the data do not include alternative health measures, which could can tell us if certain episodes of illness were underreported.

The community health characteristics have little explanatory power in the health input equations. Surprisingly, improved sanitation, improved source of water or appropriate hand washing facilities has no effect on the incidence of diarrhoea. Improved sanitation actually has an estimated negative association with non-diarrhoeal diseases. This is in contrast to a wide body of research that finds significant associations between access to water and sanitation technologies and child morbidity (Günther and Fink, 2010). On the other hand, the insignificant association between improved source of water and child illness can be explained by the fact that an improved source of drinking water is not necessarily free of microbial contamination (Bain et al., 2012)

The distance to the nearest health centre generally yields opposite signs for the two health inputs: for diarrhoea, there is a small but statistically significant positive association i.e. the further away the health centre, the more likely a lack of diarrhoea, while for non-diarrhoeal diseases, it is the other way around, i.e. the longer the distance to the nearest health centre, the higher the likelihood of other illnesses. The distance to health centre is positively associated with the consumption of iron-rich food, and negatively associated with the intake of other fruits and vegetables. As discussed above, we lack information on the quality of health services, which may provide more insight into these relationships.

There are only a few significant associations between local prices and health and nutritional inputs. The most consistent relation is with petrol, which, for the most part, has a negative correlation with the food inputs. The price of local rice has a positive association with the intake of grains, which may be due to a substitution effect. If the price of rice is high, children potentially eat more other types of grain, such as maize and millet. In fact, the prices of these foods are negatively correlated with the intake of grains, but only the correlation of millet is marginally significant.[12] Except for one input (dairy products), the community characteristics, including prices, are jointly significant in the input demand equations.

The analysis by age group is presented in Appendix tables A-2 and A-3. Most of the main results presented here hold, with a few exceptions. For younger children, the negative association of maternal agency with intake of grains remains, but the negative association with meal frequency is no longer significant. The opposite is true for the older cohort (24-59 months). In addition, for the younger children, the negative correlation between household consumption and diarrhoea is no longer significant, but for older children the effect remains.

In sum, the immediate determinants of child malnutrition, food intake and health status are strongly associated with a child's age and a few maternal characteristics, particularly agency and health. Maternal education does not make a large difference in our sample. Community characteristics are also not very powerful in the demand equations, although their joint effect is significant. The next section uses the same set of explanatory variables to estimate their direct association with nutritional outcomes.

[12] It would be useful to know if households are net producers or net consumers of these food types. Unfortunately this survey did not collect information on agricultural production.

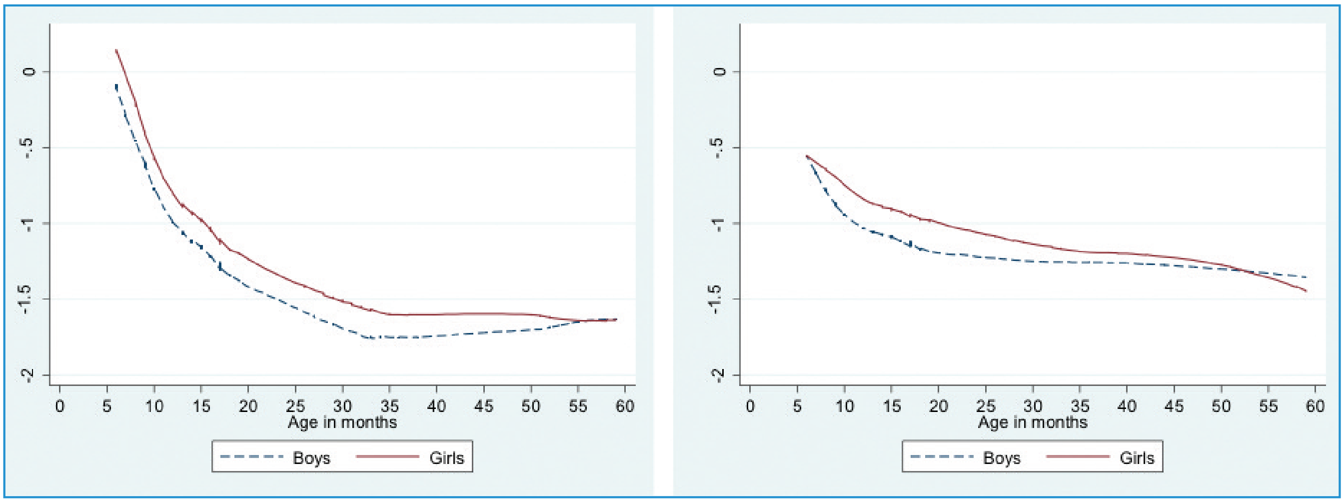
3.2 Nutritional outcomes: HAZ and WAZ (conditional demand)

The regression results of the conditional demand for nutrition are presented in Table 4 (pages 26-27). As discussed previously, the model is estimated on two nutritional outcomes height-for-age (HAZ) and weight-for-age (WAZ). HAZ is usually considered a long-term nutritional outcome, while WAZ measures both chronic and acute malnutrition (WHO Multicentre Growth Reference Study Group and Onis, 2006). For each outcome, the model is again estimated for the full sample, for the younger cohort (6-23 months) and the older cohort (24-59 months) separately, but results are only reported for the full sample in the main body of the text, whereas results by age group are reported in the Appendix in Tables A-4 and A-5.

First of all, the sex and age group dummies are significant across the board, for both HAZ and WAZ. Their signs indicate that girls have better nutritional status than boys, and that nutritional status decreases with age. This is confirmed by Figure 2, which visually presents the relation between HAZ and WAZ by age. For HAZ, the girls' line consistently lies above the boys' line, until the boys catch up around 55 months. The second graph shows that girls have better WAZ scores until around 50 months. While the boys' line is relatively flat for older boys, the line for girls continues to decrease as they get older.

Besides age and sex, children of multiple births are also significantly smaller and weigh less for their age than children of single births. This association is no longer significant in the older age group, indicating that there may be some catch-up growth for these children (see Appendix Table A-5). The other child characteristics are not correlated with nutritional status. Similar to the input demand functions, maternal characteristics have very little influence on nutritional outcomes in our data. There is no association with maternal education, and it does not seem to matter whether the father lives in the household. Again, there is a weak but significant association between the mother's age and height, and also a small positive association of the mother's agency on weight-for-age.

Figure 2 – ***Relation between HAZ, WAZ and age, for boys and girls***



Notes: Results from local linear regressions, N = 2,460 for HAZ and N= 2,435 for WAZ

In addition, nutritional knowledge and maternal self-reported health status have no association with the two nutritional status indexes. Household consumption is positively correlated with both height-for-age and weight-for-age, indicating that higher welfare is associated with better growth and development.[13] However, although the association is significant, the magnitude of the effect is quite small. For example, the coefficients show that a 10% increase in household consumption is associated with a 0.015 SD increase in HAZ-score and a 0.011 SD increase in WAZ-score.

In terms of community characteristics, only the vaccination coverage and sleeping under bed nets seem to matter for HAZ. With two exceptions, none of the prices are significant in the models, and distance to the health centre has no significant association with nutritional outcome. Taken together, child characteristics, household characteristics and community characteristics are jointly significant in both models.

There are a few differences when disaggregating the analysis by age group (Appendix Tables A-4 and A-5). For the younger cohort, there is a negative association of maternal education with HAZ, and the presence of the father in the household also has a negative association. On the other hand, the association of household consumption increases to 0.19 and remains strongly significant. For WAZ, the correlation of maternal agency becomes statistically significant, yet a marginally significant negative association appears for maternal health status. The size of the association with household consumption remains the same, but loses its significance potentially due to the smaller sample size for this model. For the older cohort, most of the estimates lose their significance and only the community characteristics remain jointly significant. This may be an indication that most of the changes in nutritional status appear in the first two years of life, consistent with the theory of the first 1,000 days.

To sum up, in our sample, children's HAZ and WAZ scores are significantly associated with age, sex and being a twin, with older children, boys, and twins having poorer z-scores. Parental characteristics seem to have little influence on nutritional outcomes, except for a positive association between the mothers' agency and WAZ. Household consumption has positive associations with both HAZ and WAZ and vaccination coverage and sleeping under a bed net is also positively correlated with HAZ. Disaggregation by age group shows that results are more pronounced for the younger cohort, suggesting that health indicators such as HAZ and WAZ are more responsive to environmental factors in the early days of life.

[13] Note that most authors would argue that household consumption is endogenous in this specification. We test for endogeneity of household consumption using assets and household characteristics as identifying instruments (first-stage robust F-test: 11.4) and find no evidence of endogeneity based on the Durbin-Wu-Hausman test (p-values >0.10, results available upon request).

Table 4 – ***OLS regression of child, paternal, household and community characteristics on height-for age and weight-for-age (children 6-59 months)***

	(1) Height-for-age	(2) Weight-for-age
Child characteristics		
Age group (ref = 6-11 months)		
12-17 months	-0.886***	-0.369***
	0.121	0.068
18-23 months	-1.621***	-0.778***
	0.183	0.143
24-35 months	-1.355***	-0.558***
	0.147	0.103
36-47 months	-1.258***	-0.459***
	0.166	0.087
48-59 months	-1.332***	-0.577***
	0.162	0.078
Sex of child (1 = female)	0.152**	0.118***
	0.061	0.039
Child is a twin	-0.667***	-0.470**
	0.228	0.201
Birth order number	-0.042	-0.027
	0.044	0.034
Number of male siblings in household	0.079	0.015
	0.052	0.038
Number of female siblings in household	0.077	0.014
	0.047	0.040
Parental characteristics		
Mother's education (ref = none)		
Some primary	-0.167	-0.044
	0.137	0.100
Primary completed or above	-0.076	-0.008
	0.109	0.087
Mother's age	0.015*	0.005
	0.008	0.006
Living with father	-0.233	-0.087
	0.178	0.116
Mother's agency (ref = Low)		
Medium	0.132	0.119*
	0.089	0.062
High	0.022	0.098
	0.103	0.061
Nutritional knowledge	0.035	0.020
	0.028	0.024
Self-reported health good/ very good/excellent	-0.088	-0.039
	0.094	0.048

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↘ Table 4 – OLS regression of child, paternal, household and community characteristics on height-for age and weight-for-age (children 6-59 months)

	(1) Height-for-age	(2) Weight-for-age
Household characteristics		
Log of AE household consumption	0.148**	0.106**
	0.062	0.046
Community characteristics		
Vaccination coverage[1]	0.392*	0.250
	0.199	0.193
Improved sanitation[1]	0.169	0.227
	0.277	0.189
Improved source of water[1]	-0.083	0.032
	0.162	0.110
Appropriate handwashing facilities[1]	-0.604	-0.260
	0.379	0.267
Mud floor[1]	0.204	0.209
	0.246	0.196
Sleep under bed net[1]	0.593**	0.112
	0.286	0.191
Distance to nearest health centre	0.027	-0.020
	0.057	0.038
Price of Guinea corn/sorghum	-0.573	-1.030**
	0.591	0.442
Price of maize	0.269	0.420
	0.494	0.361
Price of millet	0.063	0.019
	0.229	0.134
Price of rice (local)	0.420*	0.199
	0.253	0.206
Price of dried fish	-0.017	0.002
	0.014	0.010
Price of okro	-0.062	0.048
	0.050	0.036
Price of petrol	0.008	-0.131
	0.231	0.127
Observations	2460	2435
R-squared	0.139	0.078
Tests for joint significance (p-value):		
Child characteristics	0.000	0.000
Parental characteristics	0.137	0.447
Household characteristics[2]	0.025	0.019
Community characteristics	0.008	0.007

Notes: Cluster-robust standard errors in second row. Additional control variables not reported: birth interval, household size, share of women aged 12 – 49, age of head of household, sex of head of household and whether she/he ever went to school. * p<0.10 ** p<0.05 *** p<0.01. [1] Non-self community mean. [2] Includes household size, share of women aged 12-49, age of head of household, sex of head of household and whether she/he ever went to school.

4. SIMULATIONS ON CONSUMPTION GROWTH, IMPROVED MATERNAL CARE AND PRICE SHOCKS

While Ghana achieved the Millennium Development Goal (MDG) of halving the proportion of children who are underweight and wasted, the reduction in the level of stunting remained off track (UNDP and NDPC, 2015). Therefore, as we move into the era of the Sustainable Development Goals (SDGs), which call for ending all forms of malnutrition, it is important to analyse interventions that can contribute to reducing chronic malnutrition.

In this section, in order to examine the potential impacts that public policy can have on the nutritional status of children, we simulated 4 possible scenarios (3 policy interventions and 1 price shock) and their importance in reducing malnutrition, using the full models of Tables 3 and 4. Ideally, we would want to predict the impact of interventions on the inputs, and use these changes in inputs to predict changes in nutritional status. However, because we could not estimate such a two-staged model with our data, we have to predict changes in two separate models. Due to the large amount of evidence on programmes addressing the immediate determinants of malnutrition (e.g. see Bhutta et al., 2008, Bhutta et al., 2013) and the lack of evidence on interventions improving the underlying determinants (Ruel et al., 2013), these interventions focus specifically on the underlying determinants of malnutrition, namely, food security (proxied by household consumption), care for mothers, and community level prices. The choice of the four possible scenarios in this paper is based on the one hand, on the importance of these factors in the determination of immediate determinants and nutritional outcomes, and on the other hand, on Ghana-specific interventions or events. In addition, we are particularly interested in scenarios that focus on improving conditions at the household level.

For example, household consumption was found to be significantly associated with seven of the inputs and both of the nutritional outcomes and is thus an important factor to consider. Care for mothers, operationalized by agency and self-reported health status, was highly significant in the health input equations, in three of the food inputs, but less so in the nutritional outcomes. Several community prices were significant both in the input demand models, and in the nutritional outcomes. In addition, price hikes are not uncommon in Ghana, with food inflation in the vicinity of 10% and non-food inflation over 20%, on annual basis (GSS, 2016).[14] While the other community characteristics had some significant associations, we do not consider improvements in community characteristics as a potential scenario. We are aware that evidence of community-led total sanitation (CLTS) in Mali showed improvements on child health and growth (Pickering et al., 2015), while evidence from India showed no such improvement (Patil et al., 2014). Since in our sample there are a few significant associations between community characteristics and health and food inputs, we limit our focus on household-level improvements.

In addition, while distance to the health centre had a significant association with both health inputs and two food inputs, simulations on this indicator are somewhat ambiguous. What does

[14] We choose to focus on price increases rather than decreases. Price decreases can be realized when certain food or non-food items are subsidized. However, due to the consistent evidence that government subsidies are generally regressive (del Granado et al., 2012, Wodon and Zaman, 2010) and governments throughout Africa, including Ghana, are removing rather than instating subsidies, we do not consider the potential of price decreases.

'distance to health centre decreases' mean? Of course, it could be that additional health facilities are constructed and run, making them closer to households, yet this requires large investments, which are difficult to capture in a single indicator of 'distance to the nearest health facility'.

Taking all this in consideration, we can contemplate four possible scenarios. Two cash transfer interventions; one being an increase in household consumption of 20%; the other being a consumption increase equivalent to Ghana's national cash transfer scheme – the LEAP programme. The third scenario simulates improvements in the care environment for mothers by increasing her agency and improving her health. The last scenario simulates a sudden increase in prices, for example, as a result of droughts or failed harvests. Table 5 provides a summary of the parameters for each simulation.

Table 5 – ***Parameters of simulations***

Simulation		Parameters
(1)	20% increase in consumption	Increase household expenditures and food expenditure by 20% of original value
(2)	Increase in LEAP cash transfer	Increase household expenditures by monthly LEAP transfer amounts: 38 for two beneficiaries, 44 for three beneficiaries and 53 for four beneficiaries[1]
(3)	Improved care environment	Set agency at "medium" for mothers with low agency and set self-reported health at "good" for all mothers
(4)	Price increases	Increase all prices by 10%

Notes: [1]The baseline data includes the exact transfer amount for households enrolled into the LEAP programme. For comparison households, we impute the (hypothetical) transfer amount by counting the number of eligible beneficiaries in the household (number of pregnant women and infants, people with a disability, elderly, and orphans) and assigning the transfer amount accordingly.

The predictions are estimated using the full models from Tables 3 (for inputs) and Table 4 (for nutritional outcomes). For the nutritional outcomes, we estimate the predicted changes for the distribution of z-scores, as well as the rate of stunting and underweight. In policy discussions, the prevalence of stunting and underweight are often more useful than the average z-score of a population. The observed indicator values are simply substituted by the simulated value in the regression equations, while all other variables in the models are held constant. Thus, the simulated effect is the sole effect of the change in the indicator value on the dependent variable in the regression. While we have chosen our simulation scenarios using indicators that are more often than not statistically significant in the models, we acknowledge that the indicators used for the simulations are not significant in all of the models. This could be due to the fact that the indicator is truly zero (i.e. has no effect on the outcome investigated) or because the estimated coefficient is imprecise, meaning that the standard error is simply large, but the coefficient is not necessarily equal to zero.[15] We make the (strong) assumption that the second explanation is more likely in our case. Even if the first explanation is true, the estimated coefficients will be close to zero and are therefore likely to have a rather negligible effect in the simulations, alleviating concerns that coefficients that are zero are driving the results in our simulations.

[15] Typically, standard errors increase if the residual variance in the model is large (Angrist and Pischke, 2009). Note that the R-squared in our models is relatively low (and hence the residual variance large), yet this is common in nutritional analysis. In addition, standard errors increase with low variability in the underlying variables, which is the case with the community characteristics, as the non-self means are based on dummy indicators.

4.1 Results of simulations

Increased consumption (both the 20% increase and the LEAP transfer) is simulated to lead to poorer health, due to its negative association in the input demand regression. The predicted change, however, is very small, around two percent. We hypothesized that this negative effect may be due to survival bias, the mother's occupation or the inability of ultra-poor households to identify and recall illnesses in their children. If increases in household consumption go hand in hand with improved knowledge about child health or maternal agency, this effect may be reversed. On the other hand, increased household consumption is estimated to increase the quality and quantity of child food intake, although the increases are only marginal – in the range of one percent – for most of the inputs.

Improvements in consumption only have a modest, yet positive effect on nutritional status. HAZ-scores are simulated to increase by 2.1 and 1.6 percent for the 20% increase in consumption and LEAP transfer respectively and simulated changes in WAZ-scores are of comparable size. Similar findings are reported by Alderman and Garcia (1994) for Pakistan, who find a simulated reduction of 3% on stunting as a result of a 10% increase in household consumption. In Ethiopia, a simulated increase in income of 2.5% for 15 years would reduce stunting by 4% (Christiaensen and Alderman, 2004).

Improved care is simulated to increase the probability of no diarrhoea by 14 percent and the likelihood of no other illness by 5.2 per cent. Moreover, we observe positive simulated changes in exclusive breastfeeding, and the consumption of iron-rich food, grains, roots and tubers.
In contrast, the simulated effect of improved care on the intake of fruits and vegetables that are not rich in vitamin A, is negative. It could be that this is a substitution effect, as foods that are rich in vitamin A are important for growing children. In this case, when everything else is held constant (e.g. household resources), a mother with higher agency (and thus decision-making power), may choose to provide her child with more vitamin A-rich foods (as shown by the positive effect in this indicator), while at the same time reducing the amount of other fruits and vegetables. There is also a negative simulated change in the probability of eating three meals per day, which we turn back to in the discussion below.

The simulated effect of improved care on nutritional outcomes is positive, but also modest. The effect on HAZ-scores is similar in size as the 20% increase in consumption, though the simulated effect on the rate of stunting is somewhat larger at 2.3 percent. Simulation results on WAZ and underweight are also larger in size, with an increase of 3.1 percent in average WAZ-scores and a 4.1 percent reduction in underweight.

The simulation of a price shock estimates that intake of non-vitamin A-rich foods increases when prices increase, while the effect of a price shock is negative, or close to zero, for the other food inputs. We unfortunately lack the price data to back up this explanation, but it could be that this food group largely consist of foods that households consider 'inferior' and to which they resort when prices of preferred, and perhaps higher quality food items, rise.

A price shock worsens nutritional status. For example, while our price shock simulation shows no effect on the mean z-score for height-for-age, it has a 5.5 percent simulated effect on the probability of being stunted. Similarly, a 10% price increase is estimated to increase the rate of underweight in our sample by one percent. Note that the simulated price shock is a one-time event. If there are continuous price shocks over a relatively small time period, the effects on nutritional status could be even worse.

Again, we perform the same simulations for each of the two age groups separately and report the results in the Appendix (Tables A-6 and A-7). For the youngest cohort, the negative effects of consumption on health become negligible, while the positive effects of consumption on the food inputs and nutritional outcomes are similar as in the full sample. Improved care has a larger simulated effect on health status with an increased probability of nearly 19 percent on the lack of diarrhoea and six per cent increased probability of not having another illness. However, it has a slightly larger effect on the nutritional status than in the full sample, with an estimated 3.5 percent reduction in stunting and 5.4 percent reduction in underweight. For the older cohort, as expected, the simulations show less potential, with lower effects of the simulated interventions on inputs and outcomes, although the effect of consumption growth on underweight is larger than in the younger cohort. However, price shocks seem to be more important in this age group, as a 10 percent price increase is simulated to yield a nearly 11 percent increase in the rate of stunting. The disaggregation by subgroup provides support to global evidence that public policy is more likely to generate larger effects on a young sample of children, especially on those under two years.

In sum, our results show that improved maternal care could have a large impact on health status. For food intake, we find positive effects of care, and predominantly negative effects of sudden price shocks. Simulations of income increases have positive but small effects on nutritional inputs and outcomes, suggesting that income growth alone will not be able to eliminate malnutrition in Northern Ghana. These are similar to findings from other studies. Interventions aimed at younger children show more potential than interventions aimed at children older than two years.

Table 6 – *Simulation results on health and food inputs and nutritional outcomes*

Variable	Base value	(1) 20% increase in consumption		(2) LEAP transfer		(3) Improved care		(4) Price shock of 10%	
		Prediction	% change	Prediction	% change	Prediction	% change	Prediction	% change
Health inputs									
No diarrhoea	0.579	0.567	-2.1%	0.570	-1.6%	0.660	14.0%		
		[0.537,0.597]		[0.540,0.600]		[0.625,0.696]			
No other illness	0.695	0.683	-1.7%	0.687	-1.2%	0.731	5.2%		
		[0.658,0.708]		[0.662,0.712]		[0.694,0.767]			
Food inputs									
Exclusive breastfeeding	0.624	0.631	1.1%	0.629	0.8%	0.649	4.0%	0.598	-4.2%
		[0.603,0.658]		[0.601,0.657]		[0.611,0.686]		[0.552,0.643]	
Iron-rich food	0.682	0.689	1.0%	0.688	0.9%	0.683	0.1%	0.693	1.6%
		[0.660,0.719]		[0.658,0.717]		[0.637,0.730]		[0.642,0.744]	
Grains roots and tubers	0.804	0.809	0.6%	0.808	0.5%	0.811	0.9%	0.816	1.5%
		[0.781,0.836]		[0.780,0.835]		[0.775,0.846]		[0.768,0.864]	
Dairy products	0.208	0.211	1.4%	0.210	1.0%	0.191	-8.2%	0.187	-10.1%
		[0.196,0.226]		[0.196,0.225]		[0.171,0.212]		[0.162,0.212]	
Vitamin A-rich fruits and vegetables	0.697	0.702	0.7%	0.701	0.6%	0.712	2.2%	0.635	-8.9%
		[0.679,0.726]		[0.678,0.724]		[0.676,0.747]		[0.589,0.682]	
Other fruits and vegetables	0.110	0.117	6.4%	0.115	4.5%	0.103	-6.4%	0.159	44.5%
		[0.098,0.137]		[0.096,0.134]		[0.077,0.128]		[0.118,0.199]	
Meal frequency	0.448	0.462	3.1%	0.458	2.2%	0.425	-5.1%	0.405	-9.6%
		[0.433,0.491]		[0.430,0.486]		[0.393,0.458]		[0.357,0.452]	
Nutritional Outcomes									
Height-for-age	-1.279	-1.252	2.1%	-1.259	1.6%	-1.252	2.1%	-1.274	0.4%
		[-1.341,-1.162]		[-1.349,-1.169]		[-1.365,-1.139]		[-1.462,-1.087]	
Stunted	0.307	0.303	-1.3%	0.304	-1.0%	0.300	-2.3%	0.324	5.5%
		[0.282,0.324]		[0.283,0.325]		[0.274,0.326]		[0.275,0.372]	
Weight-for-age	-1.090	-1.07	1.8%	-1.075	1.4%	-1.056	3.1%	-1.132	-3.9%
		[-1.129,-1.012]		[-1.133,-1.018]		[-1.126,-0.987]		[-1.249,-1.015]	
Underweight	0.196	0.191	-2.6%	0.192	-2.0%	0.188	-4.1%	0.198	1.0%
		[0.174,0.208]		[0.176,0.209]		[0.166,0.210]		[0.164,0.233]	

Notes: Results are based on the models from Tables 3 and 4. Predictions of stunting, and underweight are based on probit models using the same independent variables as the HAZ and WAZ model. 95% prediction interval in square brackets

5. DISCUSSION

Previous research has investigated the potential of policies primarily addressing only the immediate determinants of malnutrition, health status and food intake (Bhutta et al., 2008, Bhutta et al., 2013) and has suggested that such interventions yield a maximum reduction of stunting in the range of 20-35%. To further examine what may contribute to the reduction of stunting, we have developed a health production function and modelled interventions aimed at the underlying determinants, to assess their relative importance. Since the production of child nutrition is highly complex, any model that is able to shed light on the underlying mechanisms is useful to inform policy to improve child nutritional status (Alderman and Garcia, 1994). We estimate this model on a particularly unique population – namely children in households with pregnant women or women with infants. Our data allows us to draw on a rich number of indicators to estimate this framework – unlike previous work in Ghana, which relied on GLSS or DHS data, lacking many key indicators (Alderman, 1990, Amugsi et al., 2014, Van de Poel et al., 2007), or on a relatively small amount of data (Nti and Lartey, 2008, Ruel et al., 1999).

Our results have shown that child characteristics are important factors associated with the immediate determinants (food intake and health status) in the nutrition production function. Children in older age groups are more likely to have had an illness, but are also more likely to eat the various food groups. However, child characteristics are unlikely to be directly affected by public policies. Therefore parental and household characteristics are more useful to assess.

Parental characteristics, nevertheless, were only found to be weakly correlated with the immediate determinants of malnutrition, namely food intake and health status. We found almost no association of maternal education and maternal knowledge with food intake and health status. The mother's level of agency is related to improved health and exclusive breastfeeding, but also associated with reduced demand for dairy products and appropriate meal frequency. Mothers with higher agency may have more time commitments during the day, such as running a household business. Further inspection of the data shows that agency is indeed significantly higher among mothers who are also responsible for a household enterprise, which may compromise the time they have to care for their children. Hence, higher maternal agency will likely only lead to nutritional improvements through the health pathway; not through the food intake pathway. Maternal poor health also has a negative association with the mother's children, potentially showing a genetic link or physical difficulties in taking care of children. The significant positive – though small – correlation of the mother's age with four of the inputs, provides evidence that delaying child birth could have important benefits for children's health and nutrition.

Household resources, in the form of increased household consumption, have a negative association with health status, but generally a positive association with food intake. The negative correlation with health is also observed in other datasets, and may be explained by survival bias, the mother's occupation, or the inability of ultra-poor households to identify and recall illnesses among their children. In fact, further investigation shows that the correlation between nutritional knowledge and household consumption is positive and significant.[16] In addition, Table A-1 and

[16] Correlation coefficient: 0.051, p-value: 0.012

Figure A-1 in the Appendix shows that while the association between consumption and health may be negative for the lowest consumption quintile, there is an overall positive association between consumption and health, as soon as consumption reaches a certain threshold. Since the LEAP 1000 programme targets extremely poor households, it is likely that these households have not yet reached this threshold.[17] However, the intake of each food group also increases with household consumption and for three of the food groups and in terms of meal frequency, this relation is significant. This suggests that when household consumption grows, the quality and quantity of food intake can improve too.

The community health characteristics have little explanatory power for both health status and food intake. The distance to the nearest health centre is often used as an indicator for the cost of accessing health care and, as such, may influence decisions related to seeking care. We are not, however, able to measure quality of health care and this is likely to be an additional determinant in the input demand function (Lavy et al., 1996).

The prices of common staples are considered important community factors that may influence food intake. The results for these indicators are not coherent; they are sometimes positive and sometimes negative. However, it is important to differentiate between net food producers and net food consumers: the producers benefit from higher prices, to the detriment of consumers. Most households in our sample are subsistence farmers. However, we have no information on the size of their harvests, and therefore cannot determine which of the two groups they belong to, and more importantly, whether this makes a difference in terms of input demand.

In terms of nutritional outcomes (i.e. the conditional demand for child nutrition in the health production function) we find strong age and sex effects. This is in line with existing evidence in Sub-Saharan Africa (Svedberg, 1990), which indicates that girls tend to have better z-scores than boys. It is important to note however that the sex dummy is insignificant in all the input demand functions (Table 3), and, as such, there is no evidence that girls are favoured in terms of receiving household resources. Again, we find very little evidence that parental characteristics are important in the demand for nutrition. While previous research has found significant effects of maternal education on height or HAZ (Abuya et al., 2012, Aslam and Kingdon, 2012, Chen and Li, 2009, Christiaensen and Alderman, 2004, Handa, 1999, Smith and Haddad, 2000), we find no association between the highest educated female in the household and the immediate determinants, nor a direct association with children's nutritional status. Rather, we find that the association with the mother's agency is a better indicator of her ability to improve nutritional outcomes for her children, especially through improving the health status of the child as discussed previously. Prior research has shown that improving health and nutritional knowledge may be more important than increasing educational achievement (Glewwe, 1999), yet nutritional and health knowledge is not significantly associated with nutritional status in our study. Previous work in Ghana showed that care practices were significantly related to HAZ, although quality of care was measured in a different way across studies, and not using a similar framework to that of our study

[17] The GLSS figure suggests that this threshold is around the logged consumption value of 6, which less than 1% of the households in our sample achieve.

(Ruel et al., 1999, Amugsi et al., 2014, Nti and Lartey, 2008). Household consumption is, again, positively correlated with height and weight, showing that increased resources can help to improve child nutritional status. It is important to note, however, that the estimated coefficients on household consumption are relatively small, compared to previous research. For example, in a 12-country study, the estimated coefficient of log per capita consumption on weight-for-age ranged from 0.14 to 1.20, with a mean of 0.54 and a median of 0.47 (Haddad et al., 2003). Our estimate of 0.106 (Table 4) is therefore below this range, indicating that nutritional outcomes are not so responsive to increases in income in our sample.[18]

Globally, researchers have called for a more integrated approach to address malnutrition, in the form of nutrition-sensitive programming (Ruel et al., 2013). Due to the complex nature of child growth, it is argued that no single programme working in isolation will be able to sustain considerable impacts on malnutrition. This notion is supported by our findings, which indicate that public policy – which is able to increase consumption, improve care for mothers, and keep down inflation – is likely to have a positive, yet modest, effect on nutritional inputs and outcomes. To the extent that a policy is indeed successful in addressing these underlying determinants of malnutrition, the findings in this paper show that the effects may be small. Hence complementary interventions, which work in tandem to address multiple, underlying determinants simultaneously, may have larger potential. In addition, policies aimed at younger children are found to be more effective. This is in line with global evidence that targeting interventions during the first 1,000 days of life yields the largest benefit (Bhutta et al., 2008).

In Ghana, the fight against malnutrition is primarily guided by the National Nutrition Policy; a five-year plan initiated in 2013. The main objectives of this policy are to scale up high-impact, nutrition-specific interventions, in order to address the immediate causes of malnutrition and to increase coverage of nutrition-sensitive interventions to tackle the underlying determinants of malnutrition. At the same time, the policy aims to reposition nutrition as a key development issue (Government of Ghana, 2013). Given the findings of our study, an integrated approach which focuses on underlying and immediate causes simultaneously, does indeed seem the most promising approach to addressing malnutrition.

A limitation of this study is the cross-sectional nature of the data. We were not able to address the endogeneity of the inputs in the health production function. We therefore had to resort to estimating reduced form demand functions, for inputs and nutritional status. Others have used longitudinal data to instrument the endogenous inputs with prior inputs, and lagged weight and height (De Cao, 2011, Handa and Peterman, 2015, Puentes et al., 2016). Using cross-sectional data, local market prices are often used as instruments for current health inputs. Unfortunately, such indicators did not pass the standard weak instrument tests in our study. This study is further limited by the narrow regional scope and poverty status of the sample, potentially affecting the external validity of the results. However, the living standards in our sample are in no way exclusive to the study population and similar conditions are likely to be faced by rural people in the lowest

[18] Note that our consumption measure is *per adult equivalent* and not *per capita*. If we were to use per capita consumption, our estimates would be slightly lower than presented here.

economic quintile across the African continent. Finally, while the uniqueness of the sample is an asset because it allows the study of a particularly vulnerable population, the homogeneity in the sample may have led to certain relations not showing up. For example, the non-existent relation between sanitation and health, and between maternal education and nutritional status, may be due to the lack of variability in the indicators.

Two extensions would be interesting for future research. First, it would be helpful to relax the constraint that other variables are held constant when running the simulations. For example, it could be argued that when consumption grows, indicators such as maternal agency and health also improve, creating a double effect of the change in income. It would be challenging to model all relations between the variables in the model. Second, our simulations are not able to show the cost-benefit trade-off of each intervention. We simply lack information on the costs of these interventions, needed to estimate such cost-benefit ratios.

6. CONCLUSION

This paper has presented empirical evidence of the complex mechanisms of child nutritional status in a sample of poor rural children in Northern Ghana. By modelling the reduced form equations for inputs in the health production function, as well as the conditional demand for nutrition, we show the key pathways associated with better nutrition. We find that child characteristics are important in explaining health status and food intake, as well as nutritional outcomes, and find that maternal agency and health contribute to improved health status. Household resources, in the form of consumption, are positively associated with food intake and nutritional outcomes, but negatively related to health status. Community characteristics such as WASH and other health behaviour, generally have no association with inputs and outcomes, although there are some exceptions.

We simulated several scenarios (3 policy interventions and 1 price shock), addressing the underlying determinants of malnutrition and found that income growth, improvements in maternal care and sudden price shock avoidance have a positive – but rather limited – effect on the reduction of malnutrition. Our findings are similar to previous findings in Pakistan and Ethiopia. Interventions aimed at younger children, under age two, yielded larger effects. Hence, an integrated approach using a combination of interventions, which address all the underlying determinants at the same time, is likely to hold the most promise for reducing the burden of malnutrition in Northern Ghana.

While simulations can provide important insights into the *likely* effect of an intervention, further research is needed to estimate the *actual* impacts of policy on malnutrition, using rigorous evaluation designs. Such research should also focus on the effect of policy on the underlying mechanisms that determine malnutrition, in order to understand how public policy can contribute to different elements in the complex framework of malnutrition.

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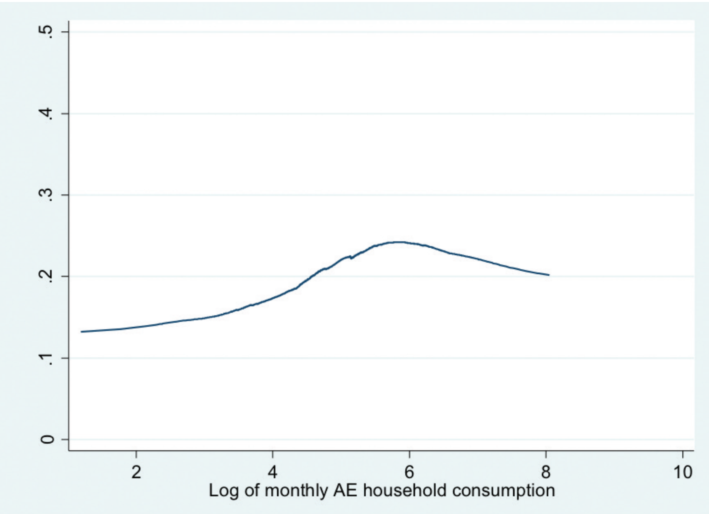
APPENDIX

Table A-1 – ***Prevalence of acute respiratory infections (ARI), fever and diarrhoea among children in the poorest and second quintile***

	Poorest quintile	Second quintile
ARI	2.6	5.0
Fever	15.5	16.6
Diarrhoea	14.1	14.4

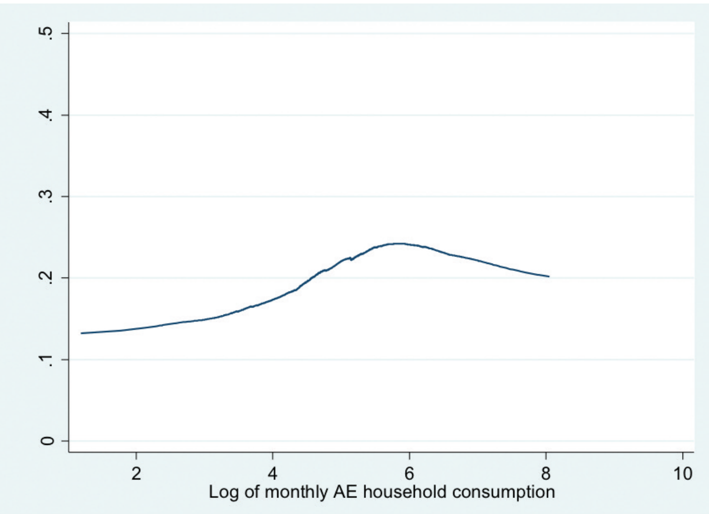
Note: Children under 5, N= 1,198 for poorest quintile, N=1,137 for second quintile
Source: Ghana Demographic and Health Survey, 2014

Figure A-1 – ***Relation between log of monthly household consumption and illness (children under 5, N=9,450)***



Source: GLSS 2012/2013

Figure A-2 – ***Relation between log of monthly household consumption and child deaths in the household (N=2,497 households)***



Source: LEAP1000 Baseline data

Table A-2 – *Marginal effects from probit models on health and nutrition inputs, children 6-23 months old*

	(1) No diarrhea in last 2 weeks	(2) No other illness in last 2 weeks	(3) Exclusive breastfeeding before 6 months	(4) Iron-rich food	(5) Grains, roots and tubers	(6) Dairy products	(7) Vitamin-A rich fruits and vegetables	(8) Other fruits and vegetables	(9) Meal frequency (at least 3 per day)
Child characteristics									
Age group (ref = 6 - 11 months)									
12 - 17 months	0.024	-0.040	-0.033	0.155***	0.145***	0.044*	0.268***	0.043**	0.075***
	0.031	0.027	0.022	0.024	0.026	0.026	0.028	0.017	0.029
18 - 23 months	-0.043	-0.022	-0.088*	0.121**	0.196***	0.082	0.335***	0.110**	0.218***
	0.049	0.043	0.046	0.052	0.037	0.052	0.044	0.045	0.062
Sex of child (1 = female)	-0.024	0.002	-0.012	-0.031	0.002	-0.010	-0.001	-0.019	-0.018
	0.028	0.026	0.023	0.030	0.029	0.025	0.026	0.013	0.026
Child is twin	-0.080	-0.081	0.173**	0.266***	0.077	-0.032	0.251**	0.013	0.024
	0.092	0.082	0.085	0.089	0.072	0.071	0.101	0.054	0.099
Birth order number	-0.026	-0.024	-0.046***	0.015	0.047***	0.017	0.012	0.009	0.017
	0.019	0.020	0.016	0.020	0.018	0.018	0.017	0.010	0.018
Number of male siblings in household	0.035	0.021	0.061***	0.005	-0.069***	-0.017	-0.022	-0.021	-0.002
	0.022	0.021	0.020	0.026	0.022	0.022	0.022	0.013	0.021
Number of female siblings in household	0.035	0.025	0.053***	-0.009	-0.055***	-0.025	-0.024	-0.018	0.001
	0.029	0.024	0.019	0.025	0.021	0.024	0.023	0.015	0.022

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➘ Table A-2 – Marginal effects from probit models on health and nutrition inputs, children 6-23 months old

	(1) No diarrhea in last 2 weeks	(2) No other illness in last 2 weeks	(3) Exclusive breastfeeding before 6 months	(4) Iron-rich food	(5) Grains, roots and tubers	(6) Dairy products	(7) Vitamin-A rich fruits and vegetables	(8) Other fruits and vegetables	(9) Meal frequency (at least 3 per day)
Parental characteristics									
Mother's education (ref = none)									
Some primary	-0.053	-0.042	0.086**	-0.001	-0.055	-0.026	0.040	-0.033*	0.047
	0.055	0.052	0.036	0.050	0.052	0.048	0.049	0.018	0.051
Primary completed or above	0.017	0.042	-0.008	-0.002	0.017	0.033	-0.046	0.004	0.036
	0.046	0.039	0.041	0.046	0.041	0.046	0.050	0.022	0.040
Mother's age	0.007*	0.004	0.003	0.003	0.004	-0.000	0.006*	0.000	0.001
	0.004	0.003	0.003	0.004	0.003	0.004	0.003	0.002	0.003
Living with father	-0.030	-0.032	-0.004	0.029	-0.126**	-0.068	-0.047	-0.015	-0.050
	0.065	0.052	0.043	0.062	0.052	0.061	0.053	0.032	0.052
Mother's agency (ref = Low)									
Medium	0.135***	0.024	0.098***	-0.011	0.058*	-0.074**	0.062*	-0.016	-0.011
	0.039	0.033	0.028	0.036	0.033	0.030	0.035	0.029	0.029
High	0.156***	0.006	0.134***	0.005	0.043	-0.085***	0.035	-0.029	-0.005
	0.046	0.037	0.035	0.041	0.039	0.032	0.038	0.027	0.038
Nutritional knowledge	-0.011	0.006	0.014	-0.004	0.007	0.015	-0.002	-0.004	-0.015
	0.012	0.010	0.010	0.011	0.010	0.011	0.011	0.006	0.011
Self-reported health good	0.205***	0.135***	0.006	0.053	-0.024	-0.041	0.034	-0.007	-0.023
very good/excellent	0.030	0.030	0.025	0.038	0.030	0.031	0.031	0.019	0.031

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Table A-2 – Marginal effects from probit models on health and nutrition inputs, children 6-23 months old

	(1) No diarrhea in last 2 weeks	(2) No other illness in last 2 weeks	(3) Exclusive breastfeeding before 6 months	(4) Iron-rich food	(5) Grains, roots and tubers	(6) Dairy products	(7) Vitamin-A rich fruits and vegetables	(8) Other fruits and vegetables	(9) Meal frequency (at least 3 per day)
Household characteristics									
Log of AE household consumption	-0.020	-0.053**	0.027	-0.005	-0.020	0.022	0.025	0.033***	0.063***
	0.023	0.021	0.019	0.025	0.022	0.026	0.025	0.011	0.023
Community characteristics									
Vaccination coverage[1]	0.051	-0.083							
	0.096	0.075							
Improved sanitation[1]	-0.189**	-0.168*							
	0.094	0.102							
Improved source of water[1]	0.073	0.082							
	0.063	0.053							
Appropriate handwashing facilities[1]	-0.038	0.437**							
	0.151	0.201							
Mud floor[1]	-0.113	0.025							
	0.092	0.069							
Slept under bednet[1]	0.230**	0.009							
	0.104	0.093							
Distance to nearest health center	0.025	-0.028*	-0.024**	0.027*	-0.006	-0.007	0.014	-0.032***	0.036***
	0.017	0.016	0.011	0.015	0.015	0.013	0.010	0.006	0.012
Price of Guinea corn/sorghum			0.029	0.183	-0.098	-0.382**	0.058	-0.083	-0.238
			0.171	0.221	0.179	0.184	0.206	0.131	0.185
Price of Maize			-0.028	0.101	-0.065	0.085	-0.122	-0.092	0.185
			0.156	0.188	0.183	0.165	0.208	0.101	0.155
Price of Millet			0.022	-0.046	-0.048	0.014	-0.083	0.040	0.069
			0.063	0.059	0.072	0.064	0.067	0.046	0.063
Price of Rice (local)			-0.094	-0.126	0.229**	0.107	0.127	0.031	0.040
			0.068	0.096	0.090	0.072	0.101	0.048	0.087
Price of Dried fish			0.003	-0.007	0.000	-0.002	-0.009**	0.002	0.005
			0.004	0.005	0.005	0.004	0.005	0.004	0.004
Price of Okro			0.013	0.027	-0.031*	0.008	-0.028	-0.002	-0.015
			0.014	0.020	0.017	0.015	0.020	0.009	0.015
Price of Petrol			-0.096**	-0.004	-0.042	-0.105**	-0.120**	0.054	-0.189***
			0.040	0.062	0.057	0.048	0.053	0.045	0.051
Observations	1282	1282	1282	1282	1282	1282	1282	1282	1282

Table A-2 – Marginal effects from probit models on health and nutrition inputs, children 6-23 months old

	(1) No diarrhea in last 2 weeks	(2) No other illness in last 2 weeks	(3) Exclusive breastfeeding before 6 months	(4) Iron-rich food	(5) Grains, roots and tubers	(6) Dairy products	(7) Vitamin-A rich fruits and vegetables	(8) Other fruits and vegetables	(9) Meal frequency (at least 3 per day)
Tests for joint significance (p-value):									
Child characteristics	0.183	0.755	0.000	0.000	0.000	0.647	0.000	0.074	0.006
Parental characteristics	0.000	0.000	0.000	0.864	0.020	0.046	0.116	0.712	0.601
Household characteristics[2]	0.228	0.203	0.018	0.079	0.164	0.399	0.079	0.000	0.184
Community characteristics	0.005	0.154	0.002	0.069	0.079	0.066	0.000	0.000	0.000

Notes: Cluster-robust standard errors in second row. Additional control variables not reported: birth interval, household size, head characteristics.

* p<0.10
** p<0.05
*** p<0.01.
[1] Non-self community mean
[2] Includes household size, share of women aged 12 – 49, age of head, sex of head and whether head ever went to school.

Table A-3 – ***Marginal effects from probit models on health and nutrition inputs, children 24-59 months old***

	(1) No diarrhea in last 2 weeks	(2) No other illness in last 2 weeks	(3) Exclusive breastfeeding before 6 months	(4) Iron-rich food	(5) Grains, roots and tubers	(6) Dairy products	(7) Vitamin-A rich fruits and vegetables	(8) Other fruits and vegetables	(9) Meal frequency (at least 3 per day)
Child characteristics									
Age group (ref = 24 - 35 months)									
36 - 47 months	0.024	0.031	0.005	-0.036	0.018	0.013	0.002	0.032	0.061*
	0.035	0.037	0.033	0.029	0.027	0.014	0.025	0.024	0.037
48 - 59 months	0.074**	0.059	-0.011	-0.066**	0.035	0.029*	0.022	0.051**	0.072**
	0.033	0.039	0.036	0.031	0.026	0.015	0.025	0.021	0.036
Sex of child (1 = female)	0.034	0.050**	0.045*	-0.010	0.009	0.015	-0.039*	0.024	0.022
	0.024	0.023	0.027	0.024	0.016	0.010	0.022	0.020	0.023
Child is twin	0.010	0.321***	0.084	0.087	0.060	0.000	0.167*	0.014	-0.099
	0.078	0.103	0.099	0.081	0.058	.	0.100	0.058	0.121
Birth order number	-0.020	0.011	-0.055***	-0.005	0.013	-0.002	-0.015	0.031**	-0.009
	0.018	0.019	0.020	0.017	0.015	0.008	0.016	0.015	0.019
Number of male siblings in household	-0.008	-0.017	0.044*	-0.025	-0.038**	-0.005	-0.001	-0.021	0.031
	0.021	0.016	0.024	0.019	0.015	0.008	0.019	0.016	0.023
Number of female siblings in household	0.005	0.002	0.050**	-0.021	-0.032**	0.003	-0.020	-0.017	0.033
	0.020	0.019	0.022	0.021	0.014	0.008	0.017	0.015	0.023

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Table A-3 – Marginal effects from probit models on health and nutrition inputs, children 24-59 months old

	(1) No diarrhea in last 2 weeks	(2) No other illness in last 2 weeks	(3) Exclusive breastfeeding before 6 months	(4) Iron-rich food	(5) Grains, roots and tubers	(6) Dairy products	(7) Vitamin-A rich fruits and vegetables	(8) Other fruits and vegetables	(9) Meal frequency (at least 3 per day)
Parental characteristics									
Mother's education (ref = none)									
Some primary	-0.094*	0.003	0.083	0.054	-0.013	-0.025**	-0.064	0.067	0.020
	0.052	0.057	0.065	0.046	0.030	0.011	0.044	0.048	0.049
Primary completed or above	0.025	0.064	0.041	0.084**	0.003	0.000	-0.000	0.037	-0.033
	0.052	0.047	0.055	0.036	0.053	.	0.037	0.036	0.054
Mother's age	0.007**	0.007*	0.001	0.006	0.002	0.002	0.004	-0.003	-0.005
	0.004	0.004	0.005	0.004	0.003	0.002	0.004	0.003	0.004
Living with father	-0.177**	-0.155	-0.012	0.021	-0.003	0.022	-0.069	-0.051	-0.009
	0.077	0.102	0.109	0.073	0.071	0.020	0.070	0.048	0.080
Mother's agency (ref = Low)									
Medium	0.105***	-0.037	0.062	-0.026	-0.008	0.000	-0.009	-0.029	-0.115***
	0.040	0.030	0.044	0.033	0.022	0.012	0.026	0.033	0.039
High	0.146***	0.007	0.137***	-0.088**	-0.011	-0.008	-0.049*	-0.033	-0.194***
	0.040	0.035	0.042	0.038	0.032	0.013	0.029	0.037	0.042
Nutritional knowledge	-0.003	0.010	0.003	0.019*	0.015	0.006	-0.015	0.004	-0.009
	0.011	0.012	0.016	0.011	0.011	0.004	0.014	0.010	0.015
Self-reported health good/very good/excellent	0.109***	0.159***	-0.013	0.017	0.009	0.005	0.002	0.016	0.003
	0.028	0.034	0.039	0.031	0.027	0.014	0.027	0.024	0.036
Household characteristics									
Log of AE household consumption	-0.117***	-0.096***	0.041	0.071***	0.052*	0.005	0.035	0.049***	0.089***
	0.026	0.031	0.032	0.024	0.027	0.012	0.022	0.018	0.026

Table A-3 – Marginal effects from probit models on health and nutrition inputs, children 24-59 months old

	(1) No diarrhea in last 2 weeks	(2) No other illness in last 2 weeks	(3) Exclusive breastfeeding before 6 months	(4) Iron-rich food	(5) Grains, roots and tubers	(6) Dairy products	(7) Vitamin-A rich fruits and vegetables	(8) Other fruits and vegetables	(9) Meal frequency (at least 3 per day)
Community characteristics									
Vaccination coverage[1]	0.026	-0.098							
	0.079	0.079							
Improved sanitation[1]	0.088	-0.175**							
	0.079	0.073							
Improved source of water[1]	0.029	0.040							
	0.051	0.050							
Appropriate handwashing facilities[1]	0.107	0.113							
	0.153	0.118							
Mud floor[1]	-0.068	0.201**							
	0.085	0.088							
Slept under bednet[1]	0.043	0.061							
	0.085	0.088							
Distance to nearest health center	0.020	-0.036***	-0.013	0.045**	-0.023	0.020**	-0.015	-0.030***	0.017
	0.013	0.014	0.022	0.022	0.015	0.008	0.014	0.011	0.025
Price of Guinea corn/sorghum			-0.345	0.756***	0.433*	0.092	0.027	0.127	-0.058
			0.329	0.293	0.231	0.098	0.173	0.183	0.289
Price of Maize			0.193	-0.162	-0.358*	-0.057	-0.169	-0.235	0.270
			0.245	0.233	0.195	0.074	0.158	0.161	0.243
Price of Millet			0.045	-0.180*	-0.253	-0.037*	-0.104*	0.054	0.022
			0.113	0.099	0.155	0.021	0.061	0.069	0.087
Price of Rice (local)			0.124	-0.144	0.336**	0.057*	0.099	-0.001	-0.223**
			0.108	0.098	0.133	0.033	0.084	0.072	0.110
Price of Dried fish			0.012*	-0.007	0.005	-0.004**	-0.006	0.003	-0.011*
			0.007	0.006	0.006	0.002	0.004	0.005	0.006
Price of Okro			0.020	0.017	-0.075***	-0.011	-0.013	0.001	0.041*
			0.021	0.021	0.020	0.007	0.016	0.016	0.024
Price of Petrol			-0.100	0.001	0.066	0.036	-0.118**	0.230***	-0.048
			0.092	0.095	0.082	0.028	0.051	0.050	0.086
Observations	1178	1178	1178	1178	1178	1036	1178	1178	1178

Table A-3 – Marginal effects from probit models on health and nutrition inputs, children 24-59 months old

	(1) No diarrhea in last 2 weeks	(2) No other illness in last 2 weeks	(3) Exclusive breastfeeding before 6 months	(4) Iron-rich food	(5) Grains, roots and tubers	(6) Dairy products	(7) Vitamin-A rich fruits and vegetables	(8) Other fruits and vegetables	(9) Meal frequency (at least 3 per day)
Tests for joint significance (p-value):									
Child characteristics	0.082	0.052	0.137	0.312	0.126	0.162	0.038	0.178	0.057
Parental characteristics	0.000	0.000	0.086	0.061	0.765	0.047	0.218	0.341	0.001
Household characteristics[2]	0.000	0.000	0.693	0.026	0.003	0.794	0.077	0.012	0.000
Community characteristics	0.353	0.000	0.000	0.000	0.010	0.029	0.000	0.000	0.030

Notes: Cluster-robust standard errors in second row. Additional control variables not reported: birth interval, household size, head characteristics. 1 Non-self community mean

Table A-4 – ***OLS regression of child, paternal, household and community characteristics on height-for-age and weight-for-age (children 6-23 months)***

	(1) Height-for-age	(2) Weight-for-age
Child characteristics		
Age group (ref = 6 - 11 months)		
12 - 17 months	-0.906***	-0.373***
	0.119	0.068
18 - 23 months	-1.637***	-0.813***
	0.187	0.135
Sex of child (1 = female)	0.210*	0.177**
	0.107	0.070
Child is twin	-0.959***	-0.847***
	0.332	0.264
Birth order number	-0.028	-0.080
	0.073	0.050
Number of male siblings in household	0.058	0.028
	0.083	0.061
Number of female siblings in household	0.064	0.049
	0.086	0.060
Parental characteristics		
Mother's education (ref = none)		
Some primary	-0.445**	-0.052
	0.211	0.143
Primary completed or above	-0.126	0.042
	0.187	0.118
Mother's age	0.017	0.007
	0.013	0.008
Living with father	-0.361*	-0.162
	0.215	0.147
Mother's agency (ref = Low)		
Medium	0.125	0.151**
	0.131	0.076
High	0.010	0.115
	0.162	0.079
Nutritional knowledge	0.069	0.034
	0.043	0.028
Self-reported health good	-0.130	-0.139*
/very good/excellent	0.127	0.074
Household characteristics		
Log of AE household consumption	0.187**	0.109
	0.092	0.069

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Table A-4 – OLS regression of child, paternal, household and community characteristics on height-for-age and weight-for-age (children 6-23 months)

	(1) Height-for-age	(2) Weight-for-age
Community characteristics		
Vaccination coverage[1]	0.565**	-0.008
	0.262	0.227
Improved sanitation[1]	0.394	0.559*
	0.485	0.304
Improved source of water[1]	-0.362	-0.063
	0.246	0.151
Appropriate handwashing facilities[1]	-0.612	-0.731**
	0.512	0.361
Mud floor[1]	0.479	0.040
	0.313	0.233
Slept under bednet[1]	0.218	-0.025
	0.415	0.268
Distance to nearest health center	-0.019	-0.063
	0.085	0.050
Price of Guinea corn/sorghum	-1.832**	-0.985
	0.825	0.599
Price of Maize	0.761	0.342
	0.650	0.483
Price of Millet	0.171	-0.087
	0.293	0.195
Price of Rice (local)	0.777**	0.254
	0.357	0.237
Price of Dried fish	-0.030	0.002
	0.022	0.014
Price of Okro	-0.007	0.053
	0.071	0.044
Price of Petrol	0.103	-0.058
	0.299	0.181
Observations	1282	1266
R-squared	0.150	0.099
Tests for joint significance (p-value):		
Child characteristics	0.000	0.000
Parental characteristics	0.056	0.088
Household characteristics[2]	0.087	0.602
Community characteristics	0.000	0.017

Notes: Cluster-robust standard errors in second row. Additional control variables not reported: birth interval, household size, head characteristics.
* p<0.10 **
p<0.05 ***
p<0.01.
[1] Non-self community mean.
[2] Includes household size, share of women aged 12 – 49, age of head, sex of head and whether head ever went to school.

Table A-5 – ***OLS regression of child, paternal, household and community characteristics on height-for-age and weight-for-age (children 24-59 months)***

	(1) Height-for-age	(2) Weight-for-age
Child characteristics		
Age group (ref = 24 - 35 months)		
36 - 47 months	0.081	0.077
	0.096	0.090
48 - 59 months	0.033	-0.033
	0.135	0.100
Sex of child (1 = female)	0.093	0.046
	0.073	0.051
Child is twin	-0.295	-0.136
	0.244	0.228
Birth order number	-0.095**	0.014
	0.043	0.038
Number of male siblings in household	0.121*	0.024
	0.062	0.044
Number of female siblings in household	0.106*	0.005
	0.058	0.047
Parental characteristics		
Mother's education (ref = none)		
Some primary	0.150	0.010
	0.133	0.130
Primary completed or above	-0.029	-0.059
	0.153	0.125
Mother's age	0.011	0.002
	0.011	0.008
Living with father	0.053	0.045
	0.295	0.233
Mother's agency (ref = Low)		
Medium	0.110	0.064
	0.117	0.087
High	0.006	0.095
	0.132	0.091
Nutritional knowledge	-0.009	0.001
	0.030	0.031
Self-reported health good	-0.074	0.049
/very good/excellent	0.105	0.061
Household characteristics		
Log of AE household consumption	0.095	0.105
	0.083	0.065

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➘ Table A-5 – OLS regression of child, paternal, household and community characteristics on height-for-age and weight-for-age (children 24-59 months)

	(1) Height-for-age	(2) Weight-for-age
Community characteristics		
Vaccination coverage[1]	0.230	0.474*
	0.281	0.259
Improved sanitation[1]	-0.002	-0.056
	0.299	0.184
Improved source of water[1]	0.166	0.113
	0.202	0.142
Appropriate handwashing facilities[1]	-0.386	0.181
	0.479	0.353
Mud floor[1]	-0.135	0.330
	0.305	0.233
Slept under bednet[1]	1.081***	0.277
	0.343	0.203
Distance to nearest health center	0.068	0.012
	0.061	0.049
Price of Guinea corn/sorghum	1.023	-0.996*
	0.809	0.549
Price of Maize	-0.608	0.408
	0.609	0.479
Price of Millet	0.028	0.127
	0.296	0.199
Price of Rice (local)	0.126	0.132
	0.317	0.261
Price of Dried fish	-0.003	0.000
	0.016	0.011
Price of Okro	-0.143**	0.046
	0.058	0.046
Price of Petrol	-0.045	-0.224
	0.271	0.168
Observations	1178	1169
R-squared	0.056	0.063
Tests for joint significance (p-value):		
Child characteristics	0.222	0.828
Parental characteristics	0.654	0.975
Household characteristics[2]	0.127	0.000
Community characteristics	0.027	0.008

Notes: Cluster-robust standard errors in second row. Additional control variables not reported: birth interval, household size, head characteristics.

* p<0.10 **
p<0.05 ***
p<0.01.
[1] Non-self community mean.
[2] Includes household size, share of women aged 12 – 49, age of head, sex of head and whether head ever went to school.

Table A-6 – *Simulation results on health and food inputs and nutritional outcomes (children 6-23 months)*

Variable	Base value	(1) 20% increase in consumption		(2) LEAP transfer		(3) Improved care		(4) Price shock of 10%	
		Prediction	% change	Prediction	% change	Prediction	% change	Prediction	% change
Health inputs									
No diarrhoea	0.502	0.499	-0.6%	0.500	-0.4%	0.597	18.9%		
		[0.457,0.541]		[0.459,0.541]		[0.546,0.648]			
No other illness	0.692	0.684	-1.2%	0.686	-0.9%	0.732	5.8%		
		[0.653,0.714]		[0.655,0.717]		[0.690,0.773]			
Food inputs									
Exclusive breastfeeding	0.774	0.778	0.5%	0.777	0.4%	0.812	4.9%	0.732	-5.4%
		[0.755,0.801]		[0.754,0.800]		[0.785,0.839]		[0.689,0.776]	
Iron-rich food	0.607	0.606	-0.2%	0.606	-0.2%	0.615	1.3%	0.612	0.8%
		[0.576,0.637]		[0.576,0.637]		[0.565,0.664]		[0.555,0.670]	
Grains roots and tubers	0.745	0.741	-0.5%	0.742	-0.4%	0.760	2.0%	0.734	-1.5%
		[0.712,0.770]		[0.714,0.770]		[0.724,0.797]		[0.676,0.792]	
Dairy products	0.372	0.376	1.1%	0.375	0.8%	0.337	-9.4%	0.326	-12.4%
		[0.351,0.400]		[0.351,0.398]		[0.303,0.371]		[0.283,0.369]	
Vitamin-A rich fruits and vegetables	0.559	0.564	0.9%	0.562	0.5%	0.589	5.4%	0.494	-11.6%
		[0.536,0.591]		[0.535,0.590]		[0.549,0.629]		[0.438,0.549]	
Other fruits and vegetables	0.080	0.085	6.3%	0.084	5.0%	0.073	-8.8%	0.093	16.3%
		[0.066,0.105]		[0.065,0.103]		[0.048,0.099]		[0.054,0.132]	
Meal frequency	0.332	0.341	2.7%	0.338	1.8%	0.323	-2.7%	0.263	-20.8%
		[0.314,0.368]		[0.312,0.365]		[0.288,0.357]		[0.216,0.311	
Nutritional Outcomes									
Height-for-age	-0.920	-0.887	3.6%	-0.896	2.6%	-0.904	1.7%	-0.856	7.0%
		[-1.023,-0.752]		[-1.031,-0.762]		[-1.060,-0.748]		[-1.101,-0.611]	
Stunted	0.260	0.256	-1.5%	0.257	-1.2%	0.251	-3.5%	0.245	-5.8%
		[0.224,0.287]		[0.226,0.288]		[0.215,0.287]		[0.192,0.298]	
Weight-for-age	-0.944	-0.924	2.1%	-0.929	1.6%	-0.920	2.5%	-0.955	-1.2%
		[-1.002,-0.847]		[-1.006,-0.853]		[-1.009,-0.831]		[-1.100,-0.809]	
Underweight	0.182	0.179	-1.6%	0.180	-1.1%	0.174	-4.4%	0.186	2.2%
	[0.155,0.203]		[0.156,0.204]		[0.143,0.204]		[0.136,0.236]		

Notes: Results are based on the models from Tables 3 and 4. Predictions of stunting, and underweight are based on probit models using the same independent variables as the HAZ and WAZ model. 95% prediction interval in square brackets.

Table A-7 – *Simulation results on health and food inputs and nutritional outcomes (children 6-23 months)*

Variable	Base value	(1) 20% increase in consumption		(2) LEAP transfer		(3) Improved care		(4) Price shock of 10%	
		Prediction	% change	Prediction	% change	Prediction	% change	Prediction	% change
Health inputs									
No diarrhoea	0.656	0.641	-2.3%	0.647	-1.4%	0.730	11.3%		
		[0.608,0.674]		[0.615,0.679]		[0.691,0.769]			
No other illness	0.685	0.683	-0.3%	0.688	0.4%	0.730	6.6%		
		[0.651,0.715]		[0.656,0.720]		[0.689,0.772]			
Food inputs									
Exclusive breastfeeding	0.452	0.470	4.0%	0.468	3.5%	0.480	6.2%	0.449	-0.7%
		[0.424,0.515]		[0.422,0.513]		[0.419,0.541]		[0.373,0.526]	
Iron-rich food	0.754	0.782	3.7%	0.779	3.3%	0.759	0.7%	0.779	3.3%
		[0.739,0.825]		[0.736,0.821]		[0.699,0.819]		[0.707,0.850]	
Grains roots and tubers	0.858	0.883	2.9%	0.880	2.6%	0.868	1.2%	0.922	7.5%
		[0.845,0.920]		[0.843,0.918]		[0.823,0.912]		[0.868,0.976]	
Dairy products	0.035	0.035	0.0%	0.035	0.0%	0.036	2.9%	0.044	25.7%
		[0.023,0.048]		[0.023,0.047]		[0.019,0.052]		[0.011,0.077]	
Vitamin-A rich fruits and vegetables	0.839	0.851	1.4%	0.850	1.3%	0.844	0.6%	0.784	-6.6%
		[0.824,0.879]		[0.823,0.877]		[0.802,0.886]		[0.723,0.845]	
Other fruits and vegetables	0.135	0.151	11.9%	0.149	10.4%	0.137	1.5%	0.235	74.1%
		[0.125,0.178]		[0.123,0.175]		[0.103,0.170]		[0.178,0.292]	
Meal frequency	0.583	0.592	1.5%	0.587	0.7%	0.532	-8.7%	0.548	-6.0%
		[0.547,0.636]		[0.544,0.631]		[0.478,0.585]		[0.477,0.620]	
Nutritional Outcomes									
Height-for-age	-1.663	-1.651	0.7%	-1.656	0.4%	-1.648	0.9%	-1.699	-2.2%
		[-1.762,-1.541]		[-1.764,-1.548]		[-1.766,-1.530]		[-1.899,-1.500]	
Stunted	0.355	0.354	-0.3%	0.355	0.0%	0.355	0.0%	0.393	10.7%
		[0.322,0.386]		[0.324,0.387]		[0.320,0.390]		[0.327,0.459]	
Weight-for-age	-1.249	-1.228	1.7%	-1.233	1.3%	-1.212	3.0%	-1.331	-6.6%
		[-1.304,-1.152]		[-1.307,-1.159]		[-1.309,-1.115]		[-1.486,-1.177]	
Underweight	0.212	0.204	-3.8%	0.205	-3.3%	0.205	-3.3%	0.210	-0.9%
		[0.178,0.229]		[0.180,0.230]		[0.171,0.240]		[0.159,0.261]	

Notes: Results are based on the models from Tables 3 and 4. Predictions of stunting, and underweight are based on probit models using the same independent variables as the HAZ and WAZ model. 95% prediction interval in square brackets.