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Child Malnutrition in Ethiopia:
Can Maternal Knowledge Augment the Role of Income

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Abstract

Over the past decades, child malnutrition in Ethiopia has persisted at alarmingly high rates. By applying the conditional nutrition demand approach to household data from three consecutive welfare monitoring surveys over the period 1996-1998, this study identifies household resources, parental education, food prices and maternal nutritional knowledge as key determinants of growth faltering in Ethiopia. Income growth is important for alleviating child stunting, though on its own it will not suffice to reach the international goal of halving each country's level of child malnutrition by 2020. Universalizing access to primary schooling for girls has slightly more promise. However, to reduce child growth faltering in Ethiopia in a significant – and timely - manner, our empirical results indicate that targeted child growth monitoring and maternal nutrition education programs will be needed in conjunction with efforts to promote private income growth and formal schooling.

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Table of Contents

1 Introduction

Nutritional status of children is a manifestation of a host of factors including household access to food and the distribution of this food within the household, availability and utilization of health services, and the care provided to the child. Several studies have explored interventions needed to increase a household's ability to address the causes of malnutrition. Interventions could focus on helping households use their resources more effectively to improve the nutritional status of their children as well as on increasing a household's resources (Strauss and Thomas, 1995).

Maternal education regularly emerges as a key element of an overall strategy to address malnutrition, having been documented, for example, in studies of the Philippines (Barrera, 1990), Pakistan (Alderman and Garcia, 1994), Ghana (Lavy et al., 1996), and Jamaica (Handa, 1999). Nevertheless, the mechanisms behind the association between mother's schooling and child health are still poorly understood. Glewwe (1999) identifies three pathways through which schooling may influence child health. First, formal education may directly transfer health knowledge to future mothers. Second, the literacy and numeracy skills acquired in school may enhance people's capability to diagnose and treat child health problems. Third, increased familiarity with modern society through schooling may make women more receptive to modern medicine. These are not mutually exclusive and are additional to the impact of schooling on household income.

Using data from Morocco Glewwe (1999) shows that mother's health knowledge alone appears to be the crucial skill in improving children's nutritional status. Moreover, he finds that such knowledge is acquired outside the classroom, though its acquisition is facilitated by the numeracy and literacy skills obtained through formal education. These findings have important policy implications. Even in communities where formal education is limited, it may be possible to impart nutritional knowledge with specific child malnutrition education programs. The current study further explores the complementary role of nutritional knowledge using mothers' capability to correctly assess their children's nutritional status as a proxy for a community's nutritional knowledge.

The study focuses on Ethiopia, a country which registers one of the highest child malnutrition rates in Sub-Saharan Africa. Nonetheless, the understanding of its causes remains limited (Subbarao and Mehra, 1997; Dercon, 1999). Obtaining a better understanding of the key determinants of child malnutrition in Ethiopia and their relative importance is thus also of importance in its own right. The paper proceeds by a brief summary of the evolution of the nutritional status of pre-school children in Ethiopia. Next, we outline our empirical approach and present a descriptive overview of the data. This is followed by a discussion of the estimated results and some policy simulations, which lead to our concluding remarks.

2 Child Malnutrition in Ethiopia

Over the past two decades substantial efforts have been made to monitor the evolution of child malnutrition in Ethiopia. Table 1 presents the main results emerging from the different nationally representative surveys. As the surveys are quite uniform in temporal[1], spatial[2] and age-group[3] coverage, the statistics are generally comparable over time. The first striking observation is the sheer magnitude of the prevalence of malnutrition of children under 5 in Ethiopia. For example, the incidence of underweight children has been consistently reported at about 45 percent, which compares with an average incidence of underweight children in Sub Saharan Africa in the nineties of 33 percent (World Bank, 2000). Similarly, surveys in Ethiopia have consistently found more than half the children under five stunted, with stunting rates most often attaining more than 60 percent. By way of comparison, during the mid nineties, the average prevalence of children stunted for 19 Sub Saharan African countries reported by Morrison et al. (2000) is 39 percent.

The data in table 1 also show that malnutrition amongst boys is consistently larger than malnutrition amongst girls, that malnutrition in rural areas is higher than in urban areas and that children in households with better educated women are better nourished. These observations are borne out irrespective of the measure of malnutrition and are consistent with the findings in the literature. Finally, we note substantial differences in the nutritional status of children amongst the regions, with child malnutrition most prevalent in Tigray and Amhara, while it is somewhat lower in Harari and Dire Dawa.

3 Empirical Approach

The theoretical framework underpinning our empirical approach is a well-known model in the tradition of Becker (1981) in which a household maximizes a utility function defined over leisure, market-purchased goods, and home produced goods such as child nutrition while facing a budget constraint, a time constraint and a biological nutrition production function. The production of nutrition depends on a set of inputs such as food (or nutrients) and the utilization of health services; a series of exogenous individual characteristics such as the child's genetic endowment, his gender and age; and a vector of household characteristics including the education of the parents, their investment in child care and the sanitation facilities available. Community characteristics such as access to and quality of health facilities may also have direct effects on nutritional outcomes.

Solution of the household's optimization problem yields a reduced form demand equation for child health status:

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

where x_i are child characteristics such as age, sex and the relation to the parents, x_h are household characteristics, such as household demographics, parental education levels, household resources and the availability of sanitation and sewerage facilities; x_c are community characteristics such as the accessibility and quality of health services and relative food prices. μ

is a random error term that represents the unobservable individual, family and community characteristics that affect the child's nutritional outcomes and is assumed to be uncorrelated with the x variables[4].

Strictly speaking, we estimate a conditional or quasi-reduced demand function (Pollack, 1971) since we proxy household resources by the logarithm of per adult equivalent expenditures. As households tend to smooth consumption, these are a better indicator of long-run resource availability than income. We predict household expenditures by two stage least squares using assets and land ownership as identifying instruments.

Alternatively, one could directly estimate the health production function. Such an approach might be preferable from a policy perspective as it provides direct insight in the relative contribution of the different inputs – nutrient intake, health clinic utilization, child care - to a child's nutritional status. Yet, inputs in child health production (such as the decision to breast feed, immunize or seek health care) are mostly endogenous. Finding appropriate identifying instruments such as the cost and quality of health care provision to address the simultaneity of input choice and health production is far from trivial (Strauss and Thomas, 1995). Consequently, most empirical studies have used conditional demand functions. While they do not reveal as much about the structural coefficients, they are still quite informative about the effects on nutrition of changes in income, parental educational attainments, community infrastructure, market prices and other factors affecting nutrition (Thomas and Strauss, 1992; Thomas, et al., 1996; Lavy, et al., 1996).

4 Child Malnutrition and Its Socio-Economic Determinants

This analysis uses individual, household- and community- level data from the 1995/6, the 1997 and the 1998 Welfare Monitoring Surveys (WMS) as well as data from the 1995/6 household income and expenditure survey (HICES) and the 1998 Health and Nutrition Survey (HNS). Both the latter surveys were conducted in conjunction with the WMS surveys. All surveys have a two or three-stage sampling design and are nationally representative. Monthly regional price data are obtained from various issues of the quarterly statistical bulletins of the Ethiopian Central Statistical Authorities.

The WMS surveys contain modules on household demographics, housing amenities, asset and land ownership, distance to facilities and child anthropometrics, as well as a limited module on household expenditures. The 1995/6 HICES survey provides detailed information for constructing comprehensive income and expenditure measures (Dercon, 1999). The 1998 NHS survey comprises modules on the health status of the different household members, mother's fertility as well as her opinion on her children's growth performance.

In the 1995/6 HICES/WMS survey information was collected on 11,687 households both in June 1995 and January 1996. The anthropometric module covered about 7,700 children each time. During the 1997 WMS which was conducted in March, about 15,000 households were surveyed and 9,081 children were measured. The 1998 WMS/NHS, which was also executed in March, was more extensive in its coverage and surveyed 45,130 households, while 30,601 children were measured. When pooled, these surveys result in a large and unique sample of 54,462 children, allowing us to combine individual nutritional outcomes with socio-economic information on the households and their communities.

Here we explore the determinants of children's long run nutrition deprivation, as measured by height for age z-scores (HAZ)[5]. Table 2 presents the sample means and standard deviations of the pooled sample for the key variables used in the analysis.

Individual and household characteristics. Children measured in the surveys are between 3 and 60 months old. There are slightly more boys than girls and about 1 percent of the children in our sample are twins.

We include educational information on both the most educated female and the most educated male adult in the household, as opposed to the educational attainments of the parents themselves. In doing so, we account for potential intra-household externalities from education, which are especially important in households at low education levels (Basu and Foster, 1998; Gibson, 2001), and circumvent the lack of information on parental educational attainments of adopted children. Inspection of table 2 shows that both the female and male adult population in Ethiopia are poorly educated. The most educated male adult member in the household has on average completed less than two years of school; the average education for the most educated female adult member is even less. Though slightly better educated, the general education level of the urban population is still very low. The most educated male and female adult have on average completed fifth and fourth grade respectively. Household members with post secondary education are only found in the cities. Three percent of the most educated women in the household and six percent of the most educated men obtained some post-secondary education.

To control for household resources, we include the predicted logarithm of total regionally deflated household expenditures per adult equivalent. Ownership of household assets and land serve as identifying instruments. Because the measure of expenditures is not comparable in all surveys (Christiaensen, 2000) we predict expenditures per adult equivalent using only the parameters derived from regressing expenditures using the 1995/6 HICES. Predicted household expenditures for 1997 and 1998 are obtained by substituting the household and locality characteristics from the 1997 and 1998 WMS into the estimated regression.[6]

Community Characteristics. We reflect the sanitary conditions in the community by the proportion of households in the cluster using flush toilets and the proportion of households who obtain their drinking water from their own tap. In urban communities 14 percent of the households use water from their own tap as drinking water, but only 3 percent possess flush toilets. In contrast, none of the rural households have tap water in their house and only 1 percent use modern toilet facilities. To eliminate potential correlation with unobserved household effects through simultaneity bias we use non-self cluster means of consumption of own tap water to drink and possession of flush toilets in the regression analysis.

To approximate the availability of health services, we use the distance to the nearest health center. This indicator – as well as its counterpart, travel time to the nearest health center - are frequently used in malnutrition studies and they are often found to affect health care choices in a manner similar to prices (Strauss and Thomas, 1995). In addition, we also incorporate monthly real relative food and fuel prices. Ideally, cluster level prices would be used as households most likely make their purchases in the nearest markets, though such prices were not available in the survey. Instead, nominal prices were obtained from various issues of the statistical bulletins of the Central Statistical Authorities and matched with the rural and urban areas in the eleven different provinces of Ethiopia. This approach assumes that markets are integrated within the region[7] and has been applied to estimate consumer price responses in Pakistan (Alderman, 1988). In total we use 28 different regional prices; one rural and at least one urban per province. Even though the general price level changed only marginally during our study period, we also deflated prices by the monthly CPI to March 1995 prices. Given large differences in regional price levels, prices were also deflated by a spatial price index, which is calculated using budget shares from the 1995/6 HICES (Dercon, 1999). Prices are presented in table 2 and include the most important food budget items: maize, teff (a local grain, *Eragrostis abyssinica*), sorghum, meat, cooking oil, milk, sugar and fuel.

5 Estimated Results: The Role of Education, Income, and Prices

Table 3 presents the estimated effects of child, household and community characteristics on child height, standardized for age and gender, using the conditional nutrition demand approach. Three models have been estimated, a base model exclusive prices as well as two additional models to examine how food and fuel prices affect a child's height for age. The reported estimates are calculated using the pooled data. We control for the survey year by including a year dummy. All estimated results are corrected for survey cluster design and the test statistics are based on heteroskedastic consistent variance-covariance matrices.

The first column in table 3 presents a base model exclusive of food and fuel prices. Consistent with Svedberg's (1990) review of child malnutrition studies in Africa, we find that boys are systematically more malnourished than girls. Their HAZ-scores are on average 0.125 points lower than those of girls.

The age coefficients imply that a child's standardized height deteriorates up to the age of three, and slightly improves afterwards, a pattern which is also observed in other developing countries (Alderman and Garcia, 1994; Handa, 1999). Twins in Ethiopia run a much larger risk of being stunted than other children. They are on average 0.42 z-scores shorter. This may be related to their lower birth weight, which is found to be an important determinant of children's long run nutritional status (Behrman and Rosenzweig, 2001). In addition - or alternatively - given the increased demands they place on their mother's time and energy, twins may not receive the same amount and quality of child care as single babies.

The importance of parental education is borne out in this study. Both female and male adult education have a large positive and statistically significant effect on the child's nutritional status[9], and the effect of female education is about twice as large as this of male education. Each year of primary or secondary education of the most educated adult in the household increases, ceteris paribus, a child's HAZ score by 0.03. Put differently, were all women to complete primary schooling, the current gap of 2.48 HAZ-points between the average HAZ score of Ethiopia's population and the standardized norm of a healthy population would be reduced by 7 percent. Post secondary schooling also has a strong and positive effect additional to the effect of primary and secondary schooling. The HAZ-score of children in households where a female adult has obtained post secondary education is on average 0.24 z-scores larger compared to households where the most educated female adult completed secondary schooling and 0.60 z-scores larger compared to households without formally educated female adults. These education effects are supplementary to the positive effects of parental education on child malnutrition through the enhancement of income.

The logarithm of per adult equivalent expenditures is included as a measure of household resources. The coefficient of expenditure is positive and statistically significant. It lies towards the upper end of the coefficient range reported by Alderman et al. (2001) based on conditional malnutrition regressions for 12 developing countries from across the world. Still, our results imply that a 10 percent increase of expenditures would remove only 1.2 percent of the gap between the current average HAZ-score in Ethiopia and the reference standard. Household size positively affects children's standardized height. Larger households may benefit from scale economies in time for child care as well as in expenditures. Alternatively, they may have become better at raising children through accumulated experience. Children's standardized height scores are not affected by the gender of the household head.

Possession of a tap and a flush toilet both have a positive effect on child height[10]. In both cases the effect is substantial, though the coefficients on flush toilets are estimated with less precision. The limited statistical significance for flush toilets may be related to lack of variation in our sample. We do not find an effect of the proximity of a health clinic on children's height. Distance to a hospital is often included to proxy the cost of obtaining health care. Yet, the quality of health care provided is equally important and not captured by this proxy, potentially explaining the lack of explanatory power of the distance variable.

To capture the role of communication infrastructure, we included the (non-self) proportion of households per cluster who own respectively a radio or a television. Ownership of a radio and/or television facilitates the acquisition of (nutritional) information allowing a more effective allocation of resources to produce child health. Radio ownership is found to positively affect children's height in our first model. Yet, this finding is not robust to the inclusion of prices. We conclude that in our sample, neither radio nor TV ownership appear to affect child height.

After controlling for child, household, and community characteristics, the geographical location of a household's residence in rural versus urban areas does not affect malnutrition in our sample. The coefficients on the year dummies on the other hand are negative, substantial and statistically significant. Table 1 indicates a large drop in average HAZ-scores reported in the 1998 WMS compared to the previous WMS surveys. While major health interventions, an overhaul of the economic environment or drought shocks may cause such a change from one year to the other, no such events occurred during our study period. To explore the issue further we include regional relative food and fuel prices in our model. As food prices in Ethiopia may fluctuate considerably from year to year due to erratic rainfall patterns, it is also of immediate policy relevance to examine the direct effect of relative food prices on chronic child malnutrition. Since prices for enset, an important staple in certain regions of Ethiopia, are not collected by the statistical authorities, we include a dummy variable which takes the value one when enset is a key staple in the regional diet. The results are presented in the second column of table 3.

Relative food prices often differ substantially across space reflecting long run geographical differences in food prices due to the agro-ecological environment and acquired tastes by the population. However, even though the price variables used in model 2 have been corrected for regional differences in *total* cost of living, the estimated coefficients on relative prices reflect both the short and long run effect of price changes on children's standardized height. To obtain estimates of the effect of short run relative price changes, we control for the longer-run expected relative price structures by including regional dummy variables. Effectively, the price coefficients reported in the third column of Table 3 indicate the impact of $[P_{jt} - \bar{P}_j]$ where j denotes region and t denotes time.

The predicting equations for household expenditures in model 2 and 3 include food and fuel prices. Thus, the direct income effect of food prices is captured through the predicted expenditures. Nevertheless, the overall effect of relative food prices on chronic child malnutrition is indeterminate. While the direction of the effect of a price increase on any given commodity is straight-forward, Pitt (1983) shows that due to cross-price effects the impact on the consumption of any nutrient may be either an increase or a decrease. Similarly, Thomas and Strauss (1992), Thomas et al. (1996) and Lavy, et al.(1996) have indicated that there is no clear pattern regarding how individual commodity prices will affect nutrition. The results in table 3 indicate that children's HAZ-scores are very responsive to relative price variations. Furthermore, short and long run price effects differ. From model two we see that higher teff, kerosene, and charcoal prices are associated with shorter children and that the effect is large and "statistically significant". The negative effect of higher teff prices on child malnutrition also holds after controlling for long run geographical price differences, though it becomes less pronounced.

Higher maize, sorghum, beef, and milk prices on the other hand are associated with taller children. To understand the positive effect of beef prices on chronic child malnutrition, note that people tend to substitute beef for other foods when beef prices decline. As calories and proteins from animal products are relatively more expensive, people's net nutrient intake tends to drop in the process. A similar process would lead to a positive association between milk prices and the height of older children. However, when accounting for geographical price differences, the signs on the sorghum and beef coefficients reverse and the coefficient on sorghum is estimated with more precision. In addition, the positive effect of higher maize prices increases.

With the exception of households' access to own tap water and radio ownership, the sign, size and statistical significance of all other coefficients are robust to the inclusion of prices and geographical dummies. This also holds for the coefficients on the time dummy variables. Inclusion of the price and/or geographical dummy variables reduces their statistical significance, though it does not eliminate their explanatory power. To examine if our findings from the pooled regressions are robust, we re-estimated our malnutrition regressions by year[13]. While the size of the coefficients may somewhat differ across the different years, the results lead us to similar conclusions as the pooled regression.

6 Maternal Nutritional Knowledge

To examine the role of maternal nutritional knowledge in child health further, we look at mothers' ability to rightly judge whether their children's growth status is normal or not as a proxy of maternal nutritional knowledge. Maternal diagnostic ability of child growth performance not only reflects a care giver's nutritional knowledge in the abstract; a correct diagnosis is also a prerequisite for corrective action and would thus be positively associated with the child's nutritional status. Information on the mother's opinion of its child's growth status is available in the 1998 Health and Nutrition Survey and the results reported below are based on that sample.

In table 4, mothers' diagnosis of their children's growth performance are cross-tabulated with their children's measured and standardized growth performance. Children are classified as stunted when their HAZ-score falls more than 2 standard deviations below the reference population. Mothers classified the growth of their children either as normal or abnormal. We consider the mother's opinion as a correct diagnostic when it conforms to the child's nutritional status. Mothers correctly evaluate their child's growth performance in only 53.7 percent of all cases. Children who are deemed to be stunted are also more likely to be stunted according to the objective anthropometric measures. On the other hand, when a mother considers the growth of her child normal, it is about equally likely to be stunted as it is not to be stunted. Thus, there is a lot of scope for improving mothers' diagnostic capabilities.

Using a dummy variable which takes unit value when the mother is right as an explanatory variable would lead to biased estimates because of correlation between this indicator and the error term. It is also not suitable to instrument the probability of the mother being right in a 2-staged least square estimation using the non-self cluster proportion of households who correctly evaluated their child's growth performance as identifying instrument. To illustrate this problem, let I = probability of the mother correctly evaluating its children's growth status = prob (mother correct), P_1 = prob (mother correct | children stunted), P_2= prob (mother correct | children not stunted) and W = probability of being stunted. I can then be expressed as I=W*P_1 + (1-W)*P_2. Clearly, I is not independent of W, which in turn likely depends on unobserved community characteristics.

Thus, in lieu of either observed or instrumented individual knowledge we use an indicator of community knowledge that does not implicitly include the average community nutritional status. In particular, we use the non-household cluster average of households' assessments of their preschool children's growth when they are stunted (HAZ <-2) as well as a separate variable for the non-household cluster average of households' assessments of their children's growth when their children are displaying a normal growth pattern.[14] For each child a mother's diagnosis takes the value one when the mother is correct (child diagnosed as stunted by the mother when it is actually stunted or child diagnosed as growing normally when it is displaying normal growth) and the value zero when she is not. The mother's assessments are subsequently averaged per household separately for all stunted and for all non-stunted children. Thus the larger is a community's assessment scores, the better is its diagnostic capability. Both indicators could be seen as our proxies for P_1 and P_2 respectively. This approach has intuitive appeal. If mothers obtain their nutritional information outside school, as suggested by Glewwe (1999), communal nutritional practices and attitudes must be key in shaping individuals' nutritional knowledge, especially in areas were radio and tv ownership are limited or virtually absent.

Since the mothers' assessment of nutritional status is not available for all three years used to estimate the results in table 3, we present the estimated results of our base model with regional prices using only the 1998 WMS in column 1 of table 5. The estimates are consistent with the results derived from the pooled regression, though the coefficient on female education is somewhat smaller and the effect of household income somewhat larger. Inclusion of the nutritional knowledge variables (model 2) does not alter the other coefficients, implying that a community's nutritional knowledge works independently of the effect of adult education, household resources, sanitation and health infrastructure and food prices. As hypothesized, a community's capability to identify growth retardation amongst stunted children leads to substantially improved height status. However, the coefficient on the community's ability to identify healthy children as non-stunted is negative, although not statistically significant in model two.[15]

This latter result may be an artifact driven by small clusters. To see this, let only two children – from different households - be stunted in a community, with only one of them correctly identified as stunted by the mother. By calculating the *non-* household average judgment per cluster for stunted children we assign a value one to the mother/household whose judgment was wrong and a value zero to the mother/household who was right, exactly the opposite of their actual values. This leads to downwardly biased coefficients. The downward bias diminishes as the number of stunted or non-stunted children in the cluster increases. To test this, we re-estimate our models excluding clusters with less than three households with stunted or less than three households with non stunted children in models 4 and 5.[16, 17]

The estimated coefficients in model 4 are similar to those in model 1, which permits us to use the restricted sample to examine the effect of community nutritional knowledge on child height. In model 5 both P_1 and P_2 positively affect children's height. For example, children in communities where all stunted children are correctly diagnosed by their mothers as stunted are on average about a quarter of a z-score taller than those in communities where none of them are identified as stunted. Though positive, the effect of making the right judgement when children are not stunted is not statistically significant, suggesting that it is mainly the community's ability to spot growth faltering when children are stunted which matters. Awareness of stunting is a prerequisite for appropriate action on the mother's part to fight it, which may explain the differential effect between P_1 and P_2.

We examine the robustness of these results in four ways. First, the coefficients on P_1 and P_2 may be capturing the effect of a community's educational stock, as opposed to its diagnostic capability of child growth. However, the estimated coefficients on P_1 and P_2 are robust to the inclusion of non-self cluster means of the (non-tertiary) educational attainments of the female and male adult population. Inclusion of a community's non-self average household income does not change the value of these coefficients either, irrespective if it is proxied through predicted income or through the direct inclusion of its identifying instruments, asset and land ownership.

Second, a mother's opinion on her child's growth status may be affected by her child's recent health status. In particular, children who have recently been ill are more likely to be diagnosed as stunted. Consequently, having been ill in the recent past increases a child's probability of being considered stunted when it is stunted ($\partial P_1/\partial$child sick>0) and it decreases its probability of being considered normal when it is growing normally($\partial P_2/\partial$child sick <0) ($\partial P_2/\partial$child sick <0). As it is reasonable to assume that poor health status in the recent past is negatively related to a child's current height, omitted variable bias would lead us to underestimate the effect of P_1 and to overestimate the effect of P_2. While health may be considered endogenous, we find that the inclusion of the incidence of diarrhea or fever over the past two weeks, or the non-self cluster mean of children's recent health status, does not change our coefficients on P_1 or P_2. This provides some assurance that our results are not driven by the children's recent health status.

Third, we tested whether using a different cutoff for malnourished and, thus, reclassifying correct and incorrect diagnoses affects the results. In particular, when HAZ $\leq$ - 3 is taken as cutoff for classifying children as stunted, which is rather conservative, we still find that children in communities where all stunted children are rightly diagnosed as stunted are 0.16 z-scores taller than those in communities where none of them is identified as stunted.

Fourth, self assessments of health often depend on the scale of reference (Groot, 2000). Subjective health perceptions, such as a mother's opinion on her child's growth status, may be as much determined by the child's relative height position within its surrounding environment as by the mother's actual nutritional knowledge. It can be conjectured that the taller the reference group, the more likely the mother will rightly diagnose her child as stunted when it is stunted and the less likely it will diagnose its growth as normal when it is growing normally. If, in addition, child height is positively associated with average child height in its community, this would cause us to overestimate the effect of P_1 and to underestimate the effect of P_2. Incorporation of the non-self cluster mean of children's height for age in model 4 - to single out the scale of reference effect, albeit by including a variable which may introduce new issues of endogeneity - reduces the effect of a community's diagnostic capability on child height. However, the effect of a community's ability to judge stunted children as stunted remains substantial. For example, a 10 percentage point increase in a community's ability to diagnose stunted children as stunted would still resort about the same effect on child height as one additional year of formal schooling of the most educated female adult in the household.

Our results appear robust to a number of potential sources of bias providing confidence that a community's nutritional knowledge is an important determinant of child malnutrition. To better understand the role of nutritional knowledge we also investigated whether the effect of nutritional knowledge is higher among households with fewer resources, that is, whether it substitutes for (or, conversely, complements) income. When we add terms for the interaction of expenditures and the community's ability to recognize malnutrition, we find that both the coefficient of non-self average of correct assessments and the interaction term are not individually significant (not shown). However they are jointly significant. The point estimate for the interaction term is negative, implying that as income rises the importance of community knowledge decreases.

It furthermore appears that nutritional knowledge matters mainly when children are most at risk of stunting, i.e. (roughly) when they are less than three years old. When we re-estimate the coefficients separately for both age groups, the coefficient on P_1 amounts to 0.36 for children under three – as opposed to 0.24 for the pooled sample. For children over three, the coefficient amounts to 0.09 and is no longer statistically significant. The coefficient on P_2 remains insignificant in both cases. These findings suggest that the ability to spot growth faltering is especially beneficial during early childhood.

7 Policy Simulations

To explore the relative importance of enhancing private incomes versus expanding access to public goods such as education, direct nutrition interventions and price stabilization programs within the particular context of Ethiopia, we simulate the marginal effect of both sustained income growth of 2.5 percent per adult equivalent over a period of 15 years and the effect of providing at least one female or male adult per household with complete primary education. Given that real per capita private consumption growth rates averaged at 1.2 percent over the past decade, simulation of the effect 2.5 percent per adult equivalent growth would provide us with an optimistic indication of what can be achieved through private income generation.

We examine the case for strengthening the nutritional knowledge in a community through child growth monitoring and/or nutritional education programs as opposed to formal schooling, by simulating the effect of an increase in communities' ability to rightly judge stunted and non-stunted children respectively as stunted and non stunted by 25 and 50 percentage points. We do so by using the parameter estimates of model 5 in table 5, which are derived from the restricted 1998 sample.

Finally, we investigate the marginal effect on chronic child malnutrition of cereal price shocks. This is important given the drought prone nature of the Ethiopian economy and sheds light on the malnutrition reducing potential of price stabilization programs. We explore in particular the effect of a 25 percent increase in real prices of maize, teff, and sorghum, corresponding to possible price increases during drier years. To simulate the effect of these interventions, we use the parameter estimates derived from our pooled sample reported in model 2 of table 3.

Rather than comparing the effect of the different child malnutrition alleviating interventions on the population's anthropometric status by their effect on the average HAZ-score, we look at their effect on the prevalence of stunting, here defined as displaying a HAZ-score of more than two standard deviations below the reference population. This effect depends not only on the size of the coefficients, but also on the initial distribution of the outcome variable. Careful inspection shows that the distribution of predicted HAZ-scores is much more condensed than that of the original HAZ observations. If measurement error were the reason for compressing the distribution of predicted HAZ-scores - and not misspecification of our model - it would be preferable to use the distribution of predicted HAZ-scores as our base. Nevertheless, to examine the sensitivity of the simulation results, table 6 shows the child malnutrition reducing potential of the different interventions using both the distribution of the observed and the predicted HAZ-scores. The effect of the different interventions when using the observed distribution can be simulated simply by adding the change in the respective determinant multiplied by its estimated coefficient to the observed HAZ-score. This yields an estimate of each child's post intervention HAZ-score because child height and the different determinants are linearly related in our regression. Estimates of predicted post intervention HAZ-scores are obtained through substituting the post intervention regressor values in the regression equation.

The effect of the different policy variables is estimated from their direct effect on chronic child malnutrition. Where appropriate, we also account for their indirect effect through income. Based on the parameters from the pooled sample, fifteen years of sustained per adult equivalent income growth of 2.5 percent, would reduce chronic child malnutrition by 3 to 6 percent, with the larger change noted for the distribution of predicted observations. Using the coefficients from the 1998 sample results in a decline in chronic child malnutrition by 3.2 to 12.2 percentage points or 6 to 19 percent. Income growth alone will be insufficient to eliminate child malnutrition in Ethiopia.

Bringing at least one female adult per household up to the primary education level would reduce stunting prevalence by 6 to 11 percent. When one also accounts for the indirect effect of education through income (in effect increasing the income growth rate *above* the initial simulation), the prevalence of stunting would decrease by 7 to 12 percent. Similar results are found for simulations based on the restricted 1998 sample. While increasing male adult education also improves child nutrition, its effect is much smaller in magnitude. Providing at least one male adult per household with primary education would reduce child stunting only by 2 to 8 percent, depending on the model used. This follows from the smaller effect of male education on child malnutrition and the fact that male adults already have more education.

Thus, both our interventions - private income growth and enhanced female adult education - would reduce the prevalence of child stunting by about 5 to 10 percent each[18]. Together, they would eliminate between 10 and 20 percent of Ethiopia's child stunting. Using the diagnostic capability of mothers as a proxy for their nutritional knowledge, we find that increasing a community's diagnostic capacity of growth performance by either 25 or 50 percentage points would reduce the prevalence of stunting in the population by 3 to 8 and 5 to 16 percent respectively, depending on the base distribution used. The effect of the latter intervention is only slightly less than that of 15 years of 2.5 percent income growth, and is 60 percent larger than the schooling effect, suggesting that the gains from enhancing nutritional knowledge amongst mothers and communities, for example, through direct child growth and nutrition education programs are considerable.

Finally, we provide some insight on the potential of price stabilization programs to reduce child malnutrition. We indicate the impact of price increases using the parameters of model 2 in table 3; an increase in cereal prices by 25 percent would increase the prevalence of child malnutrition by 4 to 5 percent. Controlling for spatial differences in relative food prices through regional dummy variables reduces the total price effect only marginally. Yet, because cereals are not only an important staple, but also an important source of income for many households in Ethiopia, changes in cereal prices also affect child malnutrition indirectly through their effect on income. In particular, net cereal producers may see their income rise when cereal prices increase, while net cereal consumers will loose. Estimating the differential effect of cereal price changes on income – and subsequently on child malnutrition - for these different groups falls beyond the scope of our study. We conclude that while higher cereal prices would deteriorate the nutritional status of children in net cereal consuming households, they may also positively affect the nutritional status of children in net cereal producing households, if the indirect income effect exceeds the direct consumption effect. The total effect on the prevalence of child stunting in Ethiopia merits further investigation.

Taken together, 15 years of 2.5 percent income growth, providing at least one female adult per household with primary education and improving communities' nutritional knowledge as reflected in enhanced diagnostic accuracy of child growth by 25 percentage points would diminish the prevalence of child stunting by 13 to 43 percent to respectively 47 or 37 percentage points, depending on the base distribution.

8 Summary and Conclusions

Over the past decades, Ethiopia has consistently faced severe pre-school child malnutrition problems, with malnutrition rates ranking amongst the worst in Sub Saharan Africa. While this has been sufficiently documented - by case studies and national official surveys - the reasons behind it are still poorly understood. This paper addressed this gap by applying the conditional or quasi-reduced nutrition demand approach to household data from three consecutive welfare monitoring surveys over the period 1996-1998. In doing so, particular attention was devoted to the role of nutritional knowledge in reducing child growth faltering.

Our estimated results identify household resources, parental education, food prices and maternal nutritional knowledge, proxied by the community's diagnostic capability of growth faltering, as key determinants of chronic child malnutrition in Ethiopia. Though largely consistent with findings from other malnutrition studies, our empirical results with respect to the community sanitation, health and communication infrastructure are less robust, possibly because of confounding factors such as the quality of health care or lack of variation in the variables.

Actions to expand access to schooling and to promote food security and income growth, are already part of Ethiopia's development program. However, as indicated by the simulation results, they will leave child malnutrition at unacceptably high levels. Moreover, it will take a considerable amount of time before they will affect pre-school child malnutrition which may contribute to a substantial reduction in lifetime earnings (Behrman and Hoddinott, 2000). In particular, the results imply that enhancing awareness of growth faltering in communities and their capability to spot it may be an effective, complementary and timely response to address growth faltering in Ethiopia. For example, increasing the community's ability to rightly diagnose stunted and non stunted children respectively as stunted and non stunted by 25 percentage points has similar effects as providing at least one female adult per household with primary education. When implemented in addition to the more general development interventions such as income growth and increased access to primary schooling described above, we find that chronic child malnutrition in Ethiopia could be reduced by up to 43 percent.

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[1] The 1995/6 Welfare Monitoring Survey comprised two rounds, respectively in June 1995 and January 1996. Malnutrition rates based on each round were virtually the same. The 1997 and 1998 Welfare Monitoring Surveys were executed between January and March. The 2000 Demographic Health Survey was executed between early February and mid June.

[2] Only rural areas were covered in the 1983 and 1992 nutrition surveys. Tigray was excluded from the survey in 1983.

[3] The 1983 and 1992 rural nutrition surveys comprise children of 6 to 59 months. The 1996, 1997 and 1998 surveys cover children of 3 to 59 months old and the 2000 Demographic Health Surveys include all children between 0 and 59 months.

[4] By assumption, we rule out selective migration on the basis of the availability of health infrastructure or more favorable food prices (Rosenzweig and Wolpin, 1988).

[5] HAZ is defined as $(h-h_r)/sd_r$ where h is the observed height of a child of a specified sex/age group, h_r is the median height in the reference population of children of that sex/age group, and sd_r is the standard deviation of height measurement for the reference population of that sex/age group. The standard reference population recommended by the World Health Organization is that of the United States National Center for Health Statistics. As several studies have indicated that less than 10 percent of the worldwide variance in height can be ascribed to genetic or racial differences (Martorell and Habicht, 1986), this reference population is appropriate. Children with a HAZ score less than –2 are usually classified as stunted.

[6]The R^2 of this predicting equation (including food and fuel prices, model 2 table 3) is 0.23. The Wald statistic for household assets and land ownership, the identifying instruments, is 10.56, indicating that finite-sample bias due to insufficient explanatory power of our instruments is negligible (Bound, Jaeger, and Baker, 1995). Household assets include ownership of a plough, a sickle, a sprayer, a tractor, farm animals, transport animals, a bicycle, motorized transport, a refrigerator and a stove. The results of the predicting equations are available upon request from the authors.

[7] Dercon (1995) provides evidence of increased *inter*regional market integration in Ethiopia following market reform and peace at the beginning of the 1990s.

[8] It is assumed that regional price differences remain constant during our study period.

[9] We note that the effect of parental education may be slightly overestimated because of unobserved family background effects. This can be controlled for by the inclusion of parental height variables. Unfortunately, such information is not available in our surveys. Strauss and Thomas (1995) report an overestimate of 15 to 25 percent of the estimated effect of education on child malnutrition in Brazil. Other evidence however from Vietnam, Pakistan and Morocco (Alderman, 2000) indicates that the effect of parental education on child stunting is robust to the inclusion of parental height variables.

[10] Access to other sources of drinking water which are generally deemed safe such as public taps and protected wells did not (positively) affect children's height. They were subsequently omitted.

[11] Our price variables have so far only been corrected for regional differences in total cost of living and not for spatial differences in relative prices.

[12] As the predicting equations for household expenditures in model 2 and 3 also include food and fuel prices, the income effect of food prices is captured through the predicted expenditures.

[13] Estimated results are available from the authors upon request.

[14] When the mother is undetermined in her child growth diagnosis, her diagnosis is classified as incorrect. Classifying all undetermined diagnoses as abnormal growth - as in table 4 - does not change the estimated results reported below.

[15] If there are no stunted or non-stunted children in the cluster, observations on the nutritional knowledge variables are replaced by their respective sample mean in model 2. However,the estimated coefficients on P_1 and P_2 remain unchanged after omitting these observations (model 3, table 5).

[16] On average there are about 16 children and 14 households per cluster. The average number of households with stunted children per cluster is 8.6, while the average number of households with non-stunted children per cluster is 7.

[17] As in model 3 (table 5), omitting observations with no stunted or non-stunted children in the cluster (model 6, table 5) does not change our conclusions regarding the estimated coefficients on P_1 and P_2.

[18] It could be argued that income also affects the amount of education acquired. Our results do not account for this indirect effect of income on chronic child malnutrition.

Table 1: Evolution of child malnutrition in Ethiopia from 1983-2000

	% children stunted [1]						% children underweight [1]						% children wasted [1]					
Period [2), 3)]	1983	1992	1996[4)]	1997	1998	2000	1983	1992	1996	1997	1998	2000	1983	1992	1996	1997	1998	2000
Sex child																		
Male	61	66	67	71	56	52	-	-	49	48	45	48	9	9	8	9	10	11
Female	59	63	64	64	54	51	-	-	45	45	40	46	8	7	7	7	8	10
Residence																		
Urban	-	-	58	55	41	42	-	-	34	37	30	34	-	-	6	9	8	6
Rural	60	64	67	69	56	53	-	-	48	48	44	49	8	8	8	8	9	11
Region																		
Tigray	-	-	73	76	58	55	-	-	55	54	53	48	-	-	9	10	14	11
Affar	-	-	48	61	57	48	-	-	45	34	31	51	-	-	18	8	10	13
Amhara	-	-	73	75	65	57	-	-	55	51	49	52	-	-	9	8	10	10
Oromiya	-	-	60	62	50	47	-	-	39	42	38	42	-	-	8	7	8	10
Somali	-	-	60	65	45	46	-	-	45	58	40	44	-	-	3	10	10	16
Benshangul-Gumuz	-	-	59	63	51	41	-	-	46	44	46	42	-	-	9	4	14	14
S.N.N.P.	-	-	68	66	57	55	-	-	49	48	40	54	-	-	6	7	7	12
Gambela [5)]	-	-	36	48	48	37	-	-	31	40	40	39	-	-	8	12	8	18
Harari [5)]	-	-	54	58	38	37	-	-	29	30	21	27	-	-	5	7	5	6
Addis Ababa	-	-	46	52	33	27	-	-	23	33	19	14	-	-	5	9	4	4
Dire Dawa [5)]	-	-	49	65	34	31	-	-	38	40	27	31	-	-	14	7	10	11
Education female adult																		
no formal education	-	-	67	69	57	53	-	-	49	48	45	50	-	-	8	8	10	11
some primary education	-	-	60	62	49	49	-	-	38	44	35	40	-	-	6	8	9	9
some post primary education	-	-	48	51	38	33	-	-	26	32	24	28	-	-	5	8	6	7
Total	**60**	**64**	**66**	**67**	**55**	**52**	-	-	**47**	**47**	**43**	**47**	**8**	**8**	**8**	**8**	**9**	**11**

[1)] stunted = height-for-age z score < –2; underweight= weight-for-age z score < –2; wasted = weight-for height z score < -2.

[2)] 1983 nutrition survey covered about 9,000 children across all rural areas except Tigray; 1992 nutrition survey covers more than 20,000 children across all rural areas; the 1995/96, 1997 and 1998 Welfare Monitoring Surveys cover about 6,000, 8,000, and 29,000 children respectively; 2000 Demographic Health Survey figures are based on about 10,450 children.

[3)] 1983 and 1992 surveys comprise 6-59 months old children; 1996, 1997 and 1998 figures comprise 3-59 months old children; 2000 figures comprise 0-59 months old children;

[4)] *1996 figures based on both 1st (June 1995) and 2nd (January 1996) round of WMS survey*

[5)] The 2000 figures for Gambela, Harari and Dire Dawa are based on only 23, 21 and 36 observations respectively.

Source: CSA, Rural Nutrition Survey, 1983; CSA, Rural Nutrition Survey, 1992; CSA, Welfare Monitoring Surveys, 1995/96, 97 and 1998; CSA and ORC Macro, Ethiopia Demographic Health Survey, 2001

Table 2: Mean and standard deviation[1)] of socio-economic determinants of child malnutrition

	National		Rural		Urban	
	Mean	S.D.	Mean	S.D.	Mean	S.D.
Child characteristics						
height for age z-score	-2.48	0.02	-2.52	0.02	-2.07	0.04
sex (1=male)	0.51	0.00	0.51	0.00	0.51	0.01
child age (months)	29.15	0.09	29.08	0.09	29.77	0.21
child age squared	1100.48	5.51	1097.01	5.93	1131.64	14.03
Percentage twins	0.95	0.08	0.89	0.09	1.56	0.27
Household characteristics						
household size	5.99	0.02	5.98	0.02	6.16	0.07
female headed household (1=yes)	0.12	0.00	0.11	0.00	0.26	0.01
highest grade completed by most educated female adult	0.80	0.02	0.41	0.02	4.30	0.15
post secondary education (1=yes) most educated fem. adult	0.00	0.00	0.00	0.00	0.03	0.00
dummy for no info on female adult education (1=missing)	0.01	0.00	0.01	0.00	0.01	0.00
highest grade completed by most educated male adult	1.85	0.04	1.48	0.03	5.16	0.15
post secondary education (1=yes) most educated male adult	0.01	0.00	0.00	0.00	0.06	0.00
dummy for no info on male adult education (1=missing)	0.10	0.00	0.09	0.00	0.18	0.01
log of household expenditure per adult equivalent	7.14	0.01	7.12	0.01	7.30	0.02
Community characteristics						
Household uses water from own tap (1=yes)	0.01	0.01	0.00	0.00	0.14	0.01
Household uses flush toilet (1=yes)	0.01	0.00	0.01	0.00	0.03	0.00
Distance to nearest health center	9.21	0.20	10.12	0.21	1.09	0.08
Household owns radio (1=yes)	0.14	0.00	0.09	0.00	0.55	0.02
Household owns tv (1=yes)	0.01	0.00	0.00	0.00	0.06	0.00
Regional prices (in Birr)[2)]						
Maize	1.16	0.01	1.17	0.01	1.72	0.01
Teff	1.95	0.01	1.98	0.01	1.71	0.01
Sorghum	1.37	0.01	1.35	0.01	1.53	0.02
cooking oil	12.81	0.04	13.06	0.04	10.55	0.11
beef meat	11.43	0.05	11.31	0.06	12.54	0.14
sheep (alive)	91.87	1.03	92.65	1.13	84.86	1.44
goat (alive)	60.38	0.16	59.94	0.16	64.29	0.82
milk (unpasteurized)	2.48	0.02	2.52	0.02	2.13	0.03
Sugar	6.96	0.01	7.13	0.01	5.47	0.05
Kerosene	2.85	0.01	3.00	0.01	1.51	0.02
Charcoal	1.5	0.01	1.51	0.01	1.19	0.01

1) Means and standard errors reported account for survey design.
2) Population weighted averages of real March 1995 prices; regionally deflated

Table 3: Estimated results of child, household and community determinants of child height for age (pooled sample)

Height for age z-scores (children 3-60 months)	without prices (1)	Short & long run price effects (2)	Short run price effects [1] (3)
Child characteristics			
sex (1=male)	-0.125	-0.125	-0.125
	(5.34)	(5.39)	(5.38)
child age (months)	-0.049	-0.048	-0.048
	(14.01)	(13.87)	(13.87)
child age squared	0.001	0.001	0.001
	(12.96)	(12.86)	(12.88)
child is twin (1=yes)	-0.420	-0.418	-0.422
	(2.37)	(2.33)	(2.35)
Household characteristics			
household size	0.043	0.037	0.035
	(5.80)	(4.82)	(4.62)
female headed household (1=yes)	0.031	0.020	0.019
	(0.53)	(0.36)	(0.34)
highest grade completed by most educated female adult	0.030	0.031	0.032
	(4.29)	(4.56)	(4.76)
post secondary education (1=yes) most educated fem. adult	0.243	0.210	0.217
	(1.88)	(1.59)	(1.66)
info on female adult education (1=no; 0=yes)	0.166	0.176	0.174
	(1.24)	(1.36)	(1.35)
Highest grade completed by most educated male adult	0.014	0.009	0.008
	(2.84)	(1.79)	(1.63)
Post secondary education (1=yes) most educated male adult	0.236	0.248	0.256
	(2.89)	(2.99)	(3.09)
info on male adult education (1=no; 0=yes)	0.169	0.145	0.143
	(2.85)	(2.51)	(2.47)
Log real household expenditure per adult equivalent[2]	0.288	0.264	0.257
	(3.63)	(3.33)	(3.20)
Community characteristics			
Sanitation, health, communication infrastructure			
Non-self proportion hhs/cluster who drink water from own tap	0.197	0.287	0.378
	(1.26)	(1.87)	(2.49)
Non-self proportion hhs/cluster with flush toilets	0.283	0.306	0.316
	(1.19)	(1.28)	(1.33)
Distance to nearest health center (<=5km) (spline)	-0.001	-0.001	0.001
	(0.08)	(0.08)	(0.07)
Distance to nearest health center (>5km) (spline)	0.003	0.004	0.002
	(0.30)	(0.37)	(0.20)
Non-self proportion hhs/cluster who own radio	0.211	-0.028	-0.086
	(1.92)	(0.26)	(0.78)
Non-self proportion hhs/cluster who own tv	0.188	0.283	0.191
	(0.76)	(1.13)	(0.76)

Absolute value of t-statistics in parentheses
[1] regional dummies are not shown
[2] predicted; household assets and land ownership are the identifying instruments

Table 3 (cont.): Estimated results of child, household and community determinants of child height for age (pooled sample)

Height for age z-scores (children 3-60 months)	without prices (1)	Short & long run price effects (2)	Short run price effects [1] (3)
Food and fuel prices			
maize		0.303	0.440
		(2.04)	(2.55)
Teff		-0.470	-0.321
		(5.57)	(3.03)
Sorghum		0.072	-0.242
		(1.02)	(1.65)
Oil		0.026	0.042
		(1.43)	(2.03)
Beef		0.035	-0.014
		(2.72)	(0.88)
Sheep		0.000	0.001
		(0.26)	(1.63)
Goat		-0.003	-0.001
		(1.00)	(0.35)
unpasteurized milk		0.042	0.124
		(0.90)	(2.42)
Sugar		-0.031	-0.046
		(0.90)	(1.05)
Kerosene		-0.129	-0.074
		(2.17)	(1.01)
Charcoal		-0.257	-0.076
		(3.61)	(0.89)
Geographical location and time			
rural (1=yes)	-0.023	-0.047	-0.247
	(0.32)	(0.46)	(1.86)
enset producing zones (1=yes)		0.385	0.135
		(7.23)	(1.16)
Year 1996 (1=yes)	-0.454	-0.361	-0.472
	(13.21)	(5.47)	(6.02)
Year 1997 (1=yes)	-0.498	-0.356	-0.410
	(11.52)	(5.06)	(4.83)
Constant	-3.792	-3.140	-2.832
	(6.38)	(5.34)	(4.17)
Observations	45751	45751	45751
R-squared	0.05	0.06	0.06

Absolute value of t-statistics in parentheses
[1] regional dummies are not shown
[2] predicted; household assets and land ownership are the identifying instruments

Table 4: Maternal diagnostic ability of child growth

# observations (row %)	HAZ score child		
Child growth as diagnosed by mother[1)]	Not stunted (HAZ ≥ -2)	Stunted (HAZ<-2)	Total
Normal	10547	9894	20411
	(51.6)	(48.4)	(100)
Abnormal	3395	4896	8291
	(40.9)*	(59.1)	(100)
Total	13942	14790	28732
	(48.5)	(51.5)	(100)

[1)] In 3.5 % of all cases the mother has no opinion. In this table we classified these cases as the mother judging abnormal growth. Children whose mothers cannot evaluate their growth performance are more likely to be stunted (55.5 %) than not.

Test of association of knowledge and nutritional status: $\chi^2 = 267.8^{**}$

Table 5: Child height for age and nutritional knowledge of the community (WMS 1998)

Height for age z-scores (children 3-60 months)	Community nutritional knowledge [2]					
	Full sample			Restricted sample		
	(1)	(2)	(3)	(4)	(5)	(6)
Child Characteristics						
sex (1=male)	-0.088	-0.089	-0.088	-0.087	-0.086	-0.087
	(3.57)	(3.65)	(3.59)	(3.38)	(3.38)	(3.41)
child age (months)	-0.073	-0.072	-0.072	-0.072	-0.070	-0.070
	(19.98)	(19.73)	(19.49)	(18.80)	(18.45)	(18.33)
child age squared	0.001	0.001	0.001	0.001	0.001	0.001
	(17.83)	(17.58)	(17.34)	(16.64)	(16.31)	(16.18)
child is twin (1=yes)	-0.648	-0.635	-0.642	-0.677	-0.655	-0.665
	(4.62)	(4.48)	(4.51)	(4.73)	(4.55)	(4.59)
Household characteristics						
household size	0.052	0.048	0.053	0.055	0.048	0.057
	(5.62)	(5.43)	(6.64)	(5.70)	(4.93)	(6.79)
female headed household (1=yes)	0.020	0.016	0.029	0.049	0.041	0.060
	(0.31)	(0.25)	(0.46)	(0.72)	(0.59)	(0.87)
highest grade completed by most educated female adult	0.016	0.016	0.014	0.012	0.013	0.011
	(2.28)	(2.23)	(2.09)	(1.66)	(1.76)	(1.48)
post secondary education (1=yes) most educated fem. adult	0.068	0.093	0.034	0.055	0.036	0.005
	(0.51)	(0.69)	(0.26)	(0.32)	(0.22)	(0.03)
info on female adult education (1=no; 0=yes)	0.349	0.350	0.354	0.309	0.311	0.313
	(2.22)	(2.24)	(2.26)	(1.82)	(1.84)	(1.84)
Highest grade completed by most educated male adult	0.008	0.009	0.007	0.006	0.008	0.005
	(1.34)	(1.62)	(1.24)	(0.99)	(1.32)	(0.83)
Post secondary education (1=yes) most educated male adult	0.248	0.255	0.235	0.268	0.271	0.242
	(2.45)	(2.52)	(2.30)	(2.26)	(2.30)	(2.02)
info on male adult education (1=no; 0=yes)	0.184	0.187	0.184	0.160	0.158	0.158
	(2.54)	(2.59)	(2.54)	(2.07)	(2.06)	(2.04)
Log real household expenditure per adult equivalent[2]	0.389	0.357	0.434	0.425	0.338	0.470
	(3.43)	(3.17)	(4.76)	(3.56)	(2.62)	(4.99)
Community characteristics						
Nutritional knowledge						
Non-self cluster average judgement/household if children not stunted		-0.076	-0.075		0.006	0.012
		(0.90)	(0.88)		(0.07)	(0.15)
No non-stunted children in cluster (1=yes; 0=no)		-1.092			-1.616	
		(4.44)			(8.11)	
Non-self cluster average judgement/household if children stunted		0.193	0.180		0.239	0.240
		(2.26)	(2.08)		(2.75)	(2.74)
No stunted children in cluster (1=yes; 0=no)		0.438			1.302	
		(1.49)			(4.46)	
Sanitation, health, communication infrastructure						
Non-self proportion hhs/cluster who drink water from own tap	0.219	0.236	0.303	0.076	0.087	0.162
	(0.96)	(1.06)	(1.32)	(0.28)	(0.33)	(0.59)
Non-self proportion hhs/cluster with flush toilets	0.082	-0.045	-0.233	0.067	-0.194	-0.379
	(0.22)	(0.12)	(0.61)	(0.16)	(0.46)	(0.88)
Distance to nearest health center (<=5km) (spline)	0.008	0.007	0.011	0.005	0.005	0.008
	(0.58)	(0.55)	(0.81)	(0.34)	(0.35)	(0.63)
Distance to nearest health center (>5km) (spline)	-0.004	-0.004	-0.007	-0.001	-0.001	-0.004
	(0.26)	(0.26)	(0.48)	(0.04)	(0.10)	(0.31)
Non-self proportion hhs/cluster who own radio	-0.130	-0.101	-0.127	-0.099	-0.073	-0.091
	(0.82)	(0.64)	(0.79)	(0.61)	(0.45)	(0.55)
Non-self proportion hhs/cluster who own tv	0.550	0.463	0.323	0.413	0.021	-0.280
	(1.46)	(1.24)	(0.84)	(0.75)	(0.05)	(0.61)
Geographical location						
rural (1=yes)	-0.050	-0.009	0.021	0.059	0.116	0.142
	(0.38)	(0.07)	(0.16)	(0.41)	(0.81)	(1.00)
enset producing zones (1=yes)	0.137	0.133	0.132	0.057	0.076	0.046
	(1.51)	(1.51)	(1.49)	(0.56)	(0.78)	(0.48)
Constant	-1.325	-1.340	-1.812	-1.742	-1.487	-2.290
	(1.43)	(1.43)	(2.17)	(1.74)	(1.38)	(2.53)
Observations	27230	27230	26789	24097	24097	23672
R-squared	0.07	0.08	0.07	0.06	0.07	0.06

Absolute value of t-statistics in parentheses;

[1] Predicted with assets and land ownership as identifying instruments;

[2] Based on WMS 1998. Estimated results for food and fuel prices are not reported. Estimated results based on the restricted sample excludes observations of clusters with less than three stunted or non-stunted children. In models (2) and (4) observations on the nutritional knowledge variables are replaced by their respective sample means if there were no stunted or non-stunted children in the cluster. In models (3) and (6) these clusters are excluded.

Table 6: Child malnutrition alleviating potential of different policy interventions

Prevalence of child stunting (%)	Original observations					Predicted observations				
		after intervention					after intervention			
Intervention	base	Direct effect	% change	total effect	% change	base	direct effect	% change	total effect	% change
Pooled sample (model 2, table 3)										
Income and formal schooling										
1) annual per adult equivalent income growth of 2.5 % for 15 yrs	63.2	61.0	-3	-	-	87.9	82.7	-6	-	-
2) at least one female adult/household educated up to primary level	63.2	59.2	-6	58.9	-7	87.9	78.4	-11	77.5	-12
3) at least one male adult/household educated up to primary level	63.2	61.9	-2	61.7	-2	87.9	86.2	-2	85.4	-3
4) joint intervention (1) & (2)	63.2	56.4	-11	-	-	87.9	71.1	-20	-	-
Cereal prices										
5) cereal price increase by 25 %	63.2	65.6	4	-	-	87.9	91.9	5	-	-
6) cereal price increase by 25 % (model3,table3)	63.2	65.4	3	-	-	87.2	91.2	5	-	-
Restricted 1998 sample (model 5, table 5)										
Income and formal schooling										
1) annual per adult equivalent income growth of 2.5 % for 15 yrs	54	50.8	-6	-		65.3	53.1	-19	-	
2) at least one female adult/household educated up to primary level	54	52.3	-3	51.3	-5	65.3	58.7	-10	55	-16
3) at least one male adult/household educated up to primary level	54	52.9	-2	52.5	-3	65.3	62.1	-5	60.1	-8
4) joint intervention (1) & (2)	54	48.8	-10	-	-	65.3	44.3	-32	-	-
Nutritional knowledge										
5) increase in proportion of right judgements by 25 % points	54	52.3	-3	-	-	65.3	59.8	-8	-	-
6) increase in proportion of right judgements by 50 % points	54	51.1	-5	-	-	65.3	54.7	-16	-	-
7) joint intervention (4) & (5)	54	46.8	-13	-	-	65.3	37.3	-43	-	-

Appendix

Table A1: Estimated results of child, household and community determinants of child height for age by sample year

Height for age z-scores (children 3-60 months) (model 1, table 3)	1996	1997	1998
Child characteristics			
sex (1=male)	-0.125	-0.166	-0.086
	(3.18)	(3.32)	(3.46)
child age (months)	-0.037	-0.042	-0.072
	(6.32)	(5.76)	(19.68)
child age squared	0.001	0.001	0.001
	(6.20)	(5.28)	(17.42)
child is twin (1=yes)	-0.252	-0.406	-0.635
	(0.80)	(1.01)	(4.66)
Household characteristics			
household size	0.045	0.038	0.066
	(3.84)	(2.66)	(7.27)
female headed household (1=yes)	0.135	-0.199	0.043
	(1.54)	(1.68)	(0.65)
highest grade completed by most educated female adult	0.035	0.030	0.010
	(2.70)	(2.89)	(1.46)
post secondary education (1=yes) most educated fem. adult	0.386	0.275	0.032
	(1.54)	(0.82)	(0.24)
info on female adult education (1=no; 0=yes)	0.132	0.074	0.340
	(0.60)	(0.35)	(2.09)
Highest grade completed by most educated male adult	0.021	-0.001	0.012
	(2.44)	(0.09)	(2.03)
Post secondary education (1=yes) most educated male adult	0.064	0.398	0.165
	(0.43)	(2.23)	(1.64)
info on male adult education (1=no; 0=yes)	0.035	0.427	0.211
	(0.39)	(3.26)	(2.88)
Log real household expenditure per adult equivalent[1)]	0.409	0.254	0.494
	(4.34)	(4.03)	(4.69)
Community characteristics			
Sanitation, health, communication infrastructure			
Non-self proportion hhs/cluster who drink water from own tap	0.445	0.098	-0.002
	(1.84)	(0.30)	(0.01)
Non-self proportion hhs/cluster with flush toilets	-0.347	0.954	-0.043
	(0.82)	(2.85)	(0.12)
Distance to nearest health center (<=5km) (spline)	-0.018	0.010	0.006
	(0.97)	(0.48)	(0.42)
Distance to nearest health center (>5km) (spline)	0.021	-0.008	-0.001
	(1.06)	(0.34)	(0.05)
Non-self proportion hhs/cluster who own radio	0.073	0.126	0.182
	(0.44)	(0.58)	(1.19)
Non-self proportion hhs/cluster who own tv	0.652	-0.397	0.659
	(1.53)	(0.90)	(1.89)
Rural (1=yes)	0.150	-0.416	-0.191
	(1.33)	(2.64)	(2.04)
Constant	-5.388	-3.862	-5.014
	(7.31)	(8.03)	(6.29)
Observations	11074	7446	27231
R-squared	0.03	0.04	0.06

Absolute value of t-statistics in parentheses

[1)] predicted; household assets and land ownership are the identifying instruments

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