Dynamics of Wasting and Underweight in Ethiopian Children

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Abstract

In Ethiopia, 9.7 percent of rural and 28.7 percent of small-town children are wasted and underweight, and undernutrition is responsible for a large percentage of childhood deaths. We use two waves of panel data, from the 2012 and 2014 Ethiopia Socioeconomic Surveys, to assess the dynamics of weight-for-height z-score, wasting, weight-for-age z-score, and underweight among children aged 6-59 months. Ordinary least squares (OLS) and fixed effects regression models are used to examine the associations of individual, household, and community factors with each outcome. The cross-sectional results, which generally parallel previous findings, suggest that child's sex, recent illnesses, household assets, and livestock ownership are correlated with nutritional status. However, many associations disappear after controlling for fixed effects; only recent illness and community access to a main road are consistently significant determinants of changes in nutrition status. Thus, changing factors traditionally identified as correlates of undernutrition may not be enough to improve children's nutrition. Further panel analysis, conditional on baseline nutrition status, shows that drivers of change are asymmetrical—a finding important for policy development.

Keywords: Ethiopia, child malnutrition, wasting, underweight, panel data analysis
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1. Introduction

Undernutrition is responsible for an estimated 3.1 million child deaths annually, most of which occur in low- and middle-income countries (Black *et al.*, 2013). Other serious consequences of childhood undernutrition are deficiencies in physical and mental development, higher susceptibility to disease, inhibited educational attainment, and diminished lifetime earning potential (Caulfield *et al.*, 2004; Victora *et al.*, 2008; Black *et al.* 2013). Accordingly, eradicating hunger and halving the proportion of underweight children were among the United Nations (UN) Millennium Development Goals for 2015 (MDGs), and continued reductions in all forms of malnutrition are set forth in the Sustainable Development Goals for 2030 (SDGs; UN 2015, UN-DESA 2016).

In addition to immediate impacts on health and survival, childhood nutritional status has been linked to educational outcomes, adult health, and economic productivity. Early childhood exposure to protein and calorie-boosting supplements in Guatemalan villages in the 1970s was positively associated with grade attainment and progression through school for women, and with reading comprehension and nonverbal cognitive tests scores for both men and women (Maluccio *et al.*, 2009). Men of the same cohort were also found to have higher hourly wages as adults if they had been exposed to the supplement before age 3 (Hoddinott et al., 2008). Data from Brazil, Guatemala, India, Philippines, and South Africa demonstrate that weight-for-age z-scores(WAZ) at age 2 are positively associated with adult height, body-mass index, years of schooling, birthweight of first offspring, and income (Victora et al., 2008).

Common indicators of undernutrition in children aged 6-59 months are stunting, wasting, and underweight, which are defined by comparing height- and weight-related z-scores with the WHO reference population.[3] Stunting

[3] The 2006 WHO child growth standards are derived from the WHO Multicenter Growth Reference Study carried out between 1997 and 2003. The study collected growth and other relevant data on 8,500 ethnically diverse, healthy, breastfed children in Brazil, Ghana, India, Norway, Oman, and the United States.

is defined by a height-for-age z-score (HAZ) below 2, which indicates chronic undernutrition and restricted growth; wasting is defined by a weight-for height z-score (WHZ) below 2 and suggests acute undernutrition or rapid weight loss (Black et al., 2008); and underweight is defined by a WAZ below 2, which can result from stunting or wasting. The MDGs used underweight as a general indicator of nutritional status and health (Black *et al.*, 2008, UN 2015). Stunting, wasting, and underweight are considered severe when z-scores are below 3.

In Ethiopia, reducing child undernutrition is a top national priority (Government of Ethiopia, 2013). Despite substantial progress over the last decade, large proportions of Ethiopian children under5 are still stunted (44.4%), wasted (9.7%), or underweight (28.7%), which together contribute to 51% of childhood deaths (Government, 2013). Understanding the determinants of childhood undernutrition in Ethiopia is paramount to achieving further reductions and accomplishing nutrition agenda goals, particularly where prevalence remains high.

Numerous cross-sectional studies have analyzed the social and economic determinants of stunting and underweight in Ethiopia (Edris, 2007; Haidar and Kogi-Makau, 2009; Alemayehu *et al.*, 2015; Degarege, Degarege, and Animut 2015; Degarege, Hailemeskel, and Erko 2015; Fekadu *et al.*, 2015), but fewer have used panel data or focused on wasting. Quisumbing (2003) and Hagos *et al.* (2014) did conduct studies in Ethiopia that undertook wasting or underweight analysis but with longer intervals between data points, different methods of sample selection, and ultimately different goals than this paper. Quisumbing (2003) used four waves of panel data from 15 Ethiopian villages to examine the effects of food aid on children's nutrition, specifically looking at differences by type of food aid (food-for-work vs. free distribution) and children's sex; both aid types had positive impacts on children's weight-for-height but differences by sex were insignificant. Using four waves of panel data to assess how climate and food production affected children's nutrition, Hagos *et al.* (2014) found that rainfall, temperature, and ecological zones were predictive of stunting and underweight but not of wasting.

Accurate targeting of nutrition interventions is necessary to efficiently prevent or alleviate undernutrition in children, thereby improving associated short and long-term outcomes. The cross-sectional and panel studies in Ethiopia mentioned above and those from other lower-middle-income countries (LMICs) have identified sometimes conflicting determinants of wasting and underweight. An analysis covering Bangladesh, Ethiopia, and Vietnam found household food insecurity to be highly and significantly positively associated with underweight prevalence in children under 5 (U5) in all three countries but with U5 wasting only in Bangladesh(Ali *et al.*, 2013). In other LMICs, household factors associated with wasting or underweight include inadequate toilet facilities and drinking water sources, large family size, possession of various household assets, and family wealth quintile (Gupta *et al.*, 2011; Ndiku *et al*., 2011; Rannan-Eliya *et al.*,2013; Aheto, 2015; and Arndt *et al.*, 2016). Associated individual factors are recent episodes of diarrheal disease, maternal education/literacy, maternal age, child's age, and child's sex (Aheto, 2015; Rannan-Eliya *et al.*, 2013). Studies in rural Senegal and Kenya also found wasting and underweight to be associated with child's sex, though the disparities favored females in the former and males in the latter (Gupta *et al.*, 2011; Ndiku *et al.* 2011).

Macroeconomic factors like natural disasters and food price shocks have been associated with negative nutrition outcomes, particularly for the poor, women, and children (Darnton-Hill and Cogill, 2010). Food price shocks were associated with U5 underweight or wasting in Mozambique, Malawi, and Bangladesh, though specific effects varied by context and household asset ownership, child's sex, and possibly receipt of food aid (Torlesse *et al.*, 2003; Hartwig and Grimm, 2012; Arndt *et al.*, 2016). Cash-transfer programs have had mixed results, generally improving HAZ but having varied or insignificant impacts on WHZ and WAZ (de Groot *et al.*, 2015).

Determinants observed in other LMICs generally hold true in Ethiopia, particularly diarrheal disease, parental education, and family size. With regard to U5 wasting, household income, breastfeeding behaviors, mother's ability to use money, a case of diarrheal disease in the last two weeks, parental education, family size, family possession of a cooperative bank savings account, maternal access to a health facility, and receiving food aid were each found to be significantly and independently associated in at least one study in Ethiopia (Quisumbing, 2003; Edris, 2007; Egata *et al.*; Alemayehu *et al.*, 2015; Degarege, Hailemeskel, and Erko, 2015; Fekadu *et al.*, 2015). Applying the same criteria for U5 underweight status, associations were found with household income, living in a female-headed household, being female, breastfeeding, having a toilet in the household, age of 12-23 months, mother's ability to use money, most common complementary foods, diarrheal disease episode in the last two weeks, parental education, family size, and living in highland or midland ecological zones (Edris, 2007; Haidarand Kogi-Makau, 2009; Hagos *et al.*, 2014; Alemayehu *et al.*, 2015; Degarege, Hailemeskel, and Erko 2015; Fekadu *et al.*, 2015).

Interestingly, while several studies suggested the season during which data were collected might explain observed prevalence of wasting, studies of this specific question generated mixed results. While Egata *et al.* (2013) found no significant association, Ferro-Luzzi *et al.* (2001) found WHZ declines among U5s during lean seasons in Southern Ethiopia, particularly for girls, and Abay and Hirvonen (2016) found significant seasonal differences in WHZ and WAZ related to whether market access is good or poor.

This paper contributes to the literature on determinants and dynamics of U5 wasting and underweight in Ethiopia by analyzing the two waves of panel data collected for the 2011/2012 and 2013/2014 Ethiopian Socioeconomic Surveys (ESS Waves 1 and 2).[4] At two-year intervals the ESS captures information on individual nutrition status, socioeconomic assets, and community/external factors. Using these data, we first analyze the cross-sectional correlates of wasting and underweight in Ethiopian rural and small-town children aged 6-59 months in 2012 and 2014. We then analyze wasting and underweight dynamics in a cohort of children aged 6-41 months in Wave 1 and 24-59 months in Wave 2. These analyses identify the individual, household, and community factors associated with nutrition status at given

[4] For analysis of stunting dynamics based on the same data, see Seff, Baird, and Jolliffe, 2016.

points in time and with changes in status over time. Our findings should help inform future efforts to improve Ethiopia's child nutrition and health outcomes.

In general, our cross-sectional results support previous findings. At the individual level, children's sex, maternal literacy, and recent illnesses were significantly associated with nutrition outcomes in most of our models. A variety of household characteristics were also repeatedly significant, such as sex and age of household head, possession of a solid roof, and livestock ownership. One community characteristic, presence of a health post, in Wave 2 was also significantly associated with all outcome variables.

Unlike the cross-sectional analysis, the fixed effects model lets us control for unobservable time-invariant factors and obtain a sense of what drives changes within individuals. This analysis of the dynamic associations between individual, household, and community characteristics and children's nutritional outcomes provides insights well-suited for informing policy; by controlling for potential confounders, we can better identify factors and populations to target with policies and interventions. However, this still should be interpreted as an association, not a causal relationship.

After controlling for fixed effects in our panel analysis, fewer factors remained significant. Illness in the last two months was significantly associated with negative changes in WHZ, wasting, WAZ, and underweight status. However, community access to a main road was associated with positive changes in WHZ and underweight status. After baseline status was controlled for, factors driving changes to or from undernourished states varied. For instance, children wasted at baseline were generally more responsive than non-wasted children to household changes they saw improvements in WHZ when they gained a solid roof or food assistance, and a decreased likelihood of wasting when they gained an improved water source or toilet; non-wasted children were not significantly affected by such changes.

In what follows, section 2 describes the study setting and data; section 3 details the analytic methodology, rationale, and limitations; section 4 discusses analysis results; and section 5 concludes.

2. Setting and Data

2.1 Study Setting

Ethiopia is the second most populous country in Africa, home to an estimated 88.4 million people, 84% of whom live in rural areas (Government, 2013). Aspiring to improve health and nutrition enroute to achieving the MDGs and reaching middle-income country status, Ethiopia implemented its first National Nutrition Program (NNP) in 2008 and its second in 2013. Demographic and Health Survey (DHS) data show improvements in childhood nutrition between 2000 and 2011, with underweight falling from 42.1% to 28.7% and wasting from 12.9% to 9.7% (Government, 2013). Nevertheless, underweight and wasting in Ethiopia are more prevalent than the regional averages for Sub-Saharan Africa (UNICEF 2014).

2.2 Data

The ESSs used here were conducted through a partnership of the Central Statistics Agency of Ethiopia and the World Bank Living Standards Measurement Study—Integrated Surveys of Agriculture team. In Wave 1, a stratified, two-stage sampling design was used to select first 290 rural and 43 small town enumeration areas (EA) and then 12 households from each EA; 3,969 households consented to interviews. Excluding 9 zones which were not sampled, Wave 1 is nationally representative for rural and small-town households and regionally representative of the four most populous regions of Amhara, Oromiya, SNNP, and Tigray. Wave 2re-interviewed 3,776 of the households from Wave 1, losing 5% of respondents to attrition.[5] We utilize data from the household and community questionnaires administered January to March 2012 for Wave 1 and February to April 2014 for Wave 2,

[5] ESS Wave 2 in 2013-2014 included all households sampled in Wave 1 and an additional 100 urban EAs. The latter were excluded from the analysis.

and from the livestock questionnaire administered in November/December of 2011 and 2013.

Within the panel of households, analysis was restricted to those with children aged 6-59 months (U5) in both waves to make the findings comparable to previous studies. Thus the analysis covered 2,480 children in Wave 1 and 2,202 in Wave 2. We also identified a cohort of 1.048 children who were 6-41 months during Wave 1 and 24-59 months during Wave 2—thus 6-59 months during both baseline and follow up. This cohort (the panel sample) allows for tracking of the dynamics in and out of wasting and underweight and drawing inferences on what drives changes.

2.3 Dependent and Independent Variables

The four outcomes of interest in this analysis are the dependent variables WHZ, WAZ, and binary indicators of wasting and underweight. Weight, height, and age in months were collected by interviewers for all children aged 6-59 months in Wave 1 and 6-83 months in Wave 2. Dates of birth were confirmed; follow-up questioning clarified discrepancies between reported and age imputed from date of birth. Weight was recorded in kilograms to the first decimal point using a hanging Salter-type scale. Height/length was recorded in centimeters to the first decimal point using a Shorrboard. Length was measured from a recumbent position for those aged 6-24 months and standing upright for all others. WHZ and WAZ were calculated using the 2006 WHO child growth standards recommended for international settings. As WHO recommends, outliers were excluded; WAZ less than -6 or greater than 5, and WHZ less than -5 or greater than 5were not included in the final sample (WHO, 2009). Children with WHZ below -2 are classified as wasted and those with WAZ below -2 as underweight. While research suggests the binary indicators of wasting and underweight are less efficient, there is no evidence suggesting any meaningful insight can be gleaned from an increase in WAZ from 3.5 to 4.5, for example (Royston et al., 2006), so the analysis comprehensively examines both outcomes.

Our aim is to identify which individual, household, and community factors are significantly associated with each outcome of interest. Independent variables tested were identified by previous studies and other relevant factors on which the ESS collected data. Individual variables include a continuous variable for child's age in months (6-59) and binary variables for child's sex, being the grandchild of the household head, living biological parents, mother's literacy, and occurrence of illnesses in the past two months. Because a nonlinear relationship has been demonstrated between child age in months and anthropometric z-scores, in all models we control for age in months, months squared, and months cubed (Cummins, 2013; Victora *et al.*, 2010).[6] While previous studies typically used mother's education, we instead examine mother's literacy as the majority of women surveyed have never attended school and are illiterate.

Numerous household variables are available for analysis due to the breadth of ESS coverage. The household questionnaire allowed for continuous variables of family size, age of household head, and average number of months of food insecurity[7], along with binary variables for sex of household head, receiving food aid[8], and self-reported experiences of shocks. Using principal component analysis, an asset index was constructed from a list of 35 household assets that when aggregated reflect a household's wealth. Additional binary variables signaling whether a household has a dirt floor, a solid roof[9], access to an improved toilet facility[10], and access to an improved

[6] Our data confirms the nonlinear relationship.

[7] Average number of months of food insecurity was determined by asking households that reported dealing with this situation at least once in the previous 12 months, "In which months of the last 12 did you experience [a situation when you did not have enough food to feed the household]?"

[8] Food aid includes the household or an individual household member receiving food or cash assistance through either food-for-work or free food programs.

[9] A solid roof is one made of iron or concrete.

[10] Improved toilet facilities are private or shared flush toilets and ventilated or non-ventilated pit latrines. Unimproved facilities are a bucket or field/forest (no facilities). WHO/JMP standards for improved sanitation facilities treat structurally improved facilities as unimproved if they are shared by more than one household (WHO, 2006).

source of drinking water[11] are included separately because the literature suggests these assets may have an independent effect on nutrition. Shocks include death or illness of a household member, losses of livestock, experience of a natural disaster[12], and increases in the price of food items or agricultural inputs in the past 12 months. The livestock questionnaire provided a final set of household variables; it asked households to report numbers owned of several types of animals. Binary variables were constructed for whether households owned at least one female cow, egg-laying hen, or milking cow.

Community variables were derived from the questionnaires completed by keyinformants with knowledge of EA infrastructure, organizations, and resources. Access to a main road, a large weekly market, a store selling basic medicines, a staffed health post, and Productive Safety Net Program (PSNP) operation within the kebele (smallest local administrative unit) make up the community variables, all of which are binary.

3. Methods

3.1 Cross-sectional Analysis

We first describe the cross-sectional methods used to examine for each wave which factors are associated with wasting, WHZ, underweight status, and WAZ. Associations are estimated for each dependent variable using OLS regression separately for each wave using the following model:

Model 1 $$Y_i = \beta_0 + \beta_1 X_{ihc} + \beta_2 X_{hc} + \beta_3 X_c + f_r + \varepsilon_{ic} \quad (1)$$

In the wasting and underweight versions of the model, Y_i is a binary indicator of wasting or underweight; in the WHZ and WAZ versions, Y_i is a

[11] Improved water sources are water piped into a dwelling, a yard, or a plot; a public tap or standpipe; a tubewell or borehole; a protected dug well or spring; bottled water; and rainwater. Unimproved sources are unprotected springs or dug wells, carts with small tanks, tanker-trucks, and surface water (WHO, 2006).

[12] Drought, flood, landslide, earthquake, fire, and heavy rains that prevented work.

continuous variable between -6 and 6.[13] All other components of the model are the same in each version: X is a set of characteristics where *i* represents the individual; *h,* signifies the household, and *c*, the community; β is a vector of coefficients to be estimated; f_r is a set of regional dummies; and ε_{ic} is the error term, clustered at the EA level due to the ESS two-stage sampling design. Use of wave-specific household weights make the results representative of rural and small-town areas in Ethiopia in 2012 and 2014. The OLS cross-sectional model is intended to test whether at a given point in time different combinations of individual, household, and community factors are associated with nutritional status. We first look at individual, household, and community factors separately before combining them.

3.2 Panel Analysis

Next, we use a fixed-effects model to exploit the panel data structure to examine factors associated with changes in the four outcomes of interest between the two waves.[14]As noted above, unlike the cross-sectional analysis, the fixed-effects modellets us control for unobservable time-invariant factors and obtain a sense of what drives changes within individuals. In analyzing the dynamic associations between individual, household, and community characteristics and children's nutritional outcomes, we can better identify factors and populations to target with policies and interventions. We also examine changes in the four outcome variables after controlling for baseline nutritional status because factors driving changes into or out of undernourished states may differ—catch-up growth in malnourished children can operate differently from the growth patterns of healthy children (Hassan, 2016). Stratifying fixed-effects analyses by baseline nutrition status allows

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[13] The binary variable models were also run with logit regression, and results were qualitatively the same as with OLS regression.

[14] Hausman tests were performed to test whether omitted variables were correlated with the variables in the model. All tests were statistically significant at p<0.01—the omitted variables were not randomly distributed with respect to the error term. This indicates that a fixed- and not random-effect model is the appropriate choice.

us to ascertain whether programs targeting prevention of malnutrition need different components from those targeting its reduction.[15]

An important limitation of fixed-effects analysis is that it only examines individuals who experienced changes in status between the two waves and cannot estimate the effect of any time-invariant observed variables, such as gender or ethnic group. Additionally, some variables may be capable of changing over time but simply do not for numerous reasons; for example, the literacy status of very few mothers changes between waves. Accordingly, the fixed-effects model covers only independent variables for which 10% or more of the sample experienced a change between Waves 1 and 2.[16]

To estimate these changes within the children who were measured in both waves—those aged 6-41 months old in Wave 1 and 24-59 months old in Wave 2 whose information for all covariates was complete—the following fixed effects model was used:

Model 2 $$Y_{it} = \beta_1 X_{it} + \beta_2 X_{ht} + \beta_3 X_{ct} + f_i + \varepsilon_{itc} \qquad \textbf{(2)}$$

As in the cross-sectional model, here Y_{it} is a binary outcome indicator for child *i* at time *t* in the wasting and underweight versions of the model and a continuous variable in the WHZ and WAZ versions. All other model components are the same in each version: X_i is a vector of individual characteristics, X_h of household characteristics; and X_c of community characteristics; f_i is an individual fixed effect; and ε_{itc} is the error term, all at time *t*. Standard errors are again clustered at the EA level and panel weights from Wave 2 are used to make the results representative of rural and small-town children age 6-41 months in 2012.

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[15] One weakness of stratifying the analysis by baseline nutrition status is the resulting smaller sample size.

[16] Variables excluded here are grandchild of household head, maternal literacy, male household head, dirt floor, TV ownership, stove ownership, milking goat ownership, commercial bank, and PSNP presence.

4. Results

4.1 Descriptive Statistics

Table 1 illustrates all outcomes and independent variables analyzed, by year of analysis and for children aged 6-59 months during each wave. Prevalence of wasting was 11% in both waves, marginally higher than the rural prevalence of 10.2 percent reported in Ethiopia's 2011 mini-DHS survey (Central Statistical Agency [Ethiopia] and ICF, 2012). Underweight prevalence was 26.9% in Wave 1 and 24.9% in Wave 2, both lower than the DHS finding of 28.7%. The average WHZ was -0.321 in Wave 1 and -0.400 in Wave 2, while average WHA was -1.277 and -1.268. Figure 1 shows changes in the distributions for WAZ and WHZ between waves.

A few findings stand out in Table 1. As noted, maternal literacy was very low at 24.1% in Wave 1 and 23.3% in Wave 2. Average household size rose from 6.08 members to 6.28, a subtle but statistically significant change. There were also significant changes in the number of households with solid roofs, improved water sources, and improved toilets, the former two increasing between waves and the last decreasing. The prevalence of many self-reported shocks declined between waves, most notably subjective food price shocks, which were more than twice as common in Wave 1 (27.4%) as in Wave 2 (12.8%).[17] Prevalence of livestock ownership was mostly stable, the largest change being a 4% increase in female cow ownership (68.6% to 72.5%). The community characteristic which underwent the greatest change was main road access, which went up from 50.3% to 64.8%.

4.2 Cross-Sectional Analysis

WHZ

Table 2 presents the OLS cross-sectional regression results predicting children's WHZ scores. All children between 6-59 months are included in each wave. Column (1) shows the relative impacts of individual

[17] This decline in subjective estimates of food price shocks is supported by objective stabilization of food prices in 2014 (Woldehanna and Tafere 2015).

characteristics[18], column (2) the impact of household characteristics, column (3) community characteristics, and column (4) the full model. Tables 3-5 follow the same format for other outcomes. For all four outcomes, differences in the effects of covariates are observed across waves. Given that both waves comprise children aged 6-59 months, the majority of these observed differences are likely due to *time* rather than *age* differences.

Starting with individual characteristics, having been ill in the last two months had a significant negative association with WHZ in the full models of both waves. This finding, and recent illness also being significantly associated with negative outcomes in the following models, supports previous research in Ethiopia and elsewhere.

Moving to household characteristics, living in a male-headed household, household head age, and having a dirt floor were negatively associated with WHZ in Wave 1. The negative association for male-headed households was repeated in Wave 2, contradicting findings in a previous study.[19] Having a solid roof and an improved toilet were positively associated with WHZ in the full models, each serving as a proxy for wealth and contributing to improved hygiene and sanitation. Two livestock-related household characteristics were significant in both models: ownership of female cows and of laying hen. As expected, both were positively associated with WHZ, the latter strongly, since owning livestock could indicate wealth and have a direct or indirect (economic) influence on nutrition.

Wasting

Being male and experiencing illness in the last two months were significantly associated with wasting in the full model for Wave 1, but neither was significant in Wave 2 (Table 3). Supporting the findings of

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[18] The variables "Father is alive" and "Mother is alive" were removed from the model. The percentage of living fathers did not change between waves, while attrition resulted in only children with living mothers being in Wave 2 (collinearity).

[19] A small regional study in northern Ethiopia by Haidar and Kogi-Makau (2009) found lower prevalence of stunting and underweight among 6-59-month-olds in male-headed than female-headed households; wasting prevalence was roughly the same.

numerous studies, having an improved water source was significantly negatively associated with wasting in the household and full models of Wave 1, but not in Wave 2. Having a solid roof was significantly negatively associated with wasting in the full model of Wave 2, reflecting its positive association with WHZ from Table 2. Female cow ownership was significantly negatively associated with wasting in the Wave 2 household model, but despite the strong association observed with WHZ in Table 2, no significant association was found between laying hen ownership and wasting. This implies that laying hen ownership is positively associated with weight-for-height but not enough to produce a change away from the wasting threshold. Curiously, self-reported natural disaster shocks in Wave 1 and food price shocks in Wave 2 were negatively associated with wasting, and community presence of a health post positively associated in Wave 2.

WAZ

Being male was significantly negatively associated with WAZ in the full models of both waves (Table 4), as was having been ill in the last two months, with large coefficients and high significance ($p<0.01$). Having a solid roof was positively associated with WAZ in the household and full models of both waves, as was score on the asset index. Female cow ownership stands out among all household findings for the high significance levels and relatively large coefficients in its positive association with WAZ in both models of each wave. Laying hen ownership was also significantly and positively associated in the household and full models of Wave 2. These and earlier findings suggest that, directly or indirectly, livestock ownership is an important determinant of childhood nutritional status in rural and small-town Ethiopia. A loss of livestock was significantly associated positively with WAZ in the full model of Wave 2—a curious finding given the direction of the association.[20]

Household characteristics with negative significant associations followed familiar patterns: In Wave 2 male-headed households and age of the

[20] Negative shocks from loss of livestock is, by definition, restricted to households that owned livestock in the past 12 months. Therefore, this finding is probably linked to the fact that we are subsampling on a “wealthier” group of individuals.

household head age were negatively associated with WAZ in both models, as were two communities characteristic: PSNP operation within the kebele, and the presence of a health post. Both were significant only in Wave 2, PSNP in the community model and the health post in the full model. Since the PSNP aims to serve the poorest communities, the negative association with WAZ likely reflects accurate targeting rather than negative impact. The same target group explains the association of a health post with lower WAZ, since this level of facility is usually found only in the poorest communities (Government, 2013).

Underweight

Using Model 1, illness in the last two months was significant and positive in both models of both waves (Table 5). As with wasting, being male was significantly positively associated with underweight status in the full model of Wave 1. Being the grandchild of the household head had a significant negative association with underweight in the full model of Wave 1; in Wave 2, having a literate mother had a similar significant negative association in Wave 2, but only in the individual model.

Significant associations between household characteristics and underweight status closely mirrored those for WAZ (Table 4)—moreso than was true of the wasting and WHZ results. Across all models and waves, having a solid roof had a significant negative association with underweight. Milking cows and laying hens were negatively associated with underweight in both models of Wave 2, again suggesting a significant relationship between livestock assets and nutritional status. In both models and waves, the asset index was also negatively associated with underweight. Positive associations were also familiar, with male-headed households and household head age strongly significant in both models of Wave 2 and death or illness of a household member significant in both models of Wave 1. Of community characteristics, only health post presence was significant, this time positively associated with underweight in Wave 2.

4.3 Panel Analysis

With regard to nutritional status across time, individuals surveyed in both ESS waves fall into four categories; as shown in Table 6, only 1.92% of the panel sample (18 U5 children) were wasted at both baseline and follow-up; 13.02% (121) were wasted in Wave 1 but recovered by Wave 2; 7.07% (66) were not wasted in Wave 1 but became wasted by Wave 2; and 77.99% (725) were not wasted at either point. Given the acute nature of wasting, it is possible (though not probable), that many children fell in and out of wasting status at multiple points during the two-year survey period—unlike being underweight, which can relate to either wasting or stunting and is a more general malnutrition indicator. That would explain why in the sample more children, 12.23% (128) were underweight at both baseline and follow-up: 16.18% (170) were underweight in Wave 1 but recovered by Wave 2, 11.29% became underweight between waves, and 60.3% (632) were not underweight at either point. That more children recovered from wasting or underweight status between waves than fell into either is a positive indicator for children’s nutrition in Ethiopia, but it also raised the question of why some children became less well-nourished or remained malnourished.

WHZ

Table 7 presents the fixed effects regression results predicting changes in children’s WHZ scorebased on Equation 2. Children aged 6-41 months in Wave 1 and 24-59 months in Wave 2 comprise the sample population, which is weighted to make results representative of rural and small-town areas. As in the cross-section tables, the fixed effects results are subdivided into individual, household, and community, and the full model. Tables 8-10 follow the same format for their outcome variables, as do Tables 7a-10a, with additional subdivisions by baseline status.

Controlling for fixed effects, we found two characteristics significantly associated with changes in WHZ. The association with illness in the past two months was negative in the full model, as it was in the full models of the cross-sectional WHZ results. The combination of these findings suggests that recent illness was an important risk factor for lower WHZ at both points in time as well as across time (we will discuss this after examining the remaining outcomes). The second significant variable found was main road access, a community characteristic not significant in any cross-sectional results but here positively associated with WHZ. In Table 7a, main road access continues to have a significant positive association for the wasted at baseline subgroup, suggesting that improving community access to outside services via main roads may have broad benefits for children's WHZ. Among other significant factors (Table 7a) were changes in possession of a solid roof and receipt of food assistance, which were both positively associated with WHZ in children wasted at baseline. In contrast, death or illness of a household member had a significant negative impact on WHZ among those wasted at baseline—an unfortunate yet unsurprising finding, slightly buoyed by the fact that this factor did not drag down the WHZ of children not wasted at baseline.

Wasting

With Model 2 (Table 8), while having a solid roof was significantly associated with such positive outcomes as higher WHZ and lower likelihood of wasting in our cross-sectional models, we found a significant positive association between solid roof ownership and wasting in our fixed effects models, as well as among those not wasted at baseline (Table 8a).[21] More intuitive are the results for gaining an improved toilet and water source (Table 8a): after controlling for fixed effects, those who gained these household assets and were wasted at baseline were more likely to recover than those who did not. Experiencing a food price shock in the last 12 months was, oddly, also strongly predictive of recovery from wasting; death or illness of a household member was strongly predictive of remaining wasted.

WAZ and underweight

Table 9 presents the fixed effects regression results predicting changes in children's WAZ and table 10 for underweight status, both using Model 2. Illness in the last two months was significantly negatively associated with

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[21] These results may be spurious due to the small sample of those gaining or losing access to a solid roof.

WAZ after controlling for fixed effects, with high significance and a relatively large coefficient in both individual and full models. In both models, illness was also significantly positively associated with underweight. Such associations, found in cross-sectional and fixed effects analysis for all outcome variables, strongly suggest recent illness is a serious risk factor for Ethiopian children being or becoming undernourished. Interestingly, after controlling for baseline underweight status (Tables 9a and 10a), recent illness is only significantly associated with a negative change in WAZ among children not underweight at baseline.

Together, these finding raise serious questions about responses to illness in U5s, if medical attention is sought, if feeding decreases, if unsafe or otherwise ineffective remedies are attempted, and so on. These questions warrant both further research in rural and small-town Ethiopian contexts and consideration by policy makers addressing U5 nutrition, health, and healthcare.

In addition to recent illness, several other factors were associated with changes in WAZ (Table 9a). After controlling for fixed effects, individuals not underweight at baseline were more likely to see WAZ decrease when they received food aid or lived in a community with a health post. Children underweight at baseline were more likely to see WAZ decrease when a household member died or was seriously ill. Among children not underweight at baseline, the family gaining a laying hen or community access to a main road appeared to be support their remaining at a healthy weight. Combined with the earlier findings for WHZ and wasting, making communities more accessible via connection to a main road may be a strategy for improving or protecting children's nutritional status.

6. Conclusions

Our cross-sectional findings generally agree with previous studies, particularly those using data from Ethiopia. Male children, those with male and older household heads, and those experiencing illness in the last two months were significantly more likely to have negative nutrition outcomes (lower WAZ or WHZ scores or a higher likelihood of wasting and underweight).Meanwhile, having a solid roof, a female cow, or a laying hen repeatedly were significantly associated with positive outcomes. Most community characteristics were insignificant, but having a health post was significantly associated with negative outcomes for all variables, probably because they are located in poorer communities.

Some differences from previous studies are worth noting, however. First, we find better WHZ, WAZ, and underweight outcomes for children in female-headed households, unlike regional studies in Ethiopia (Alemayehu *et al.*, 2015; Haidar and Kogi-Makau 2009) and Kenya (Ndiku *et al.*, 2012). However, the reason for female headship can provide insight into household's wellbeing. In our sample, the majority of female household heads are monogamously married (rather than widowed) and may be receiving financial transfers from their migrant worker husbands, which would help give the household's financial stability and the ability to invest more in child health. There is also a body of literature that documents the relatively higher investments female household heads make in the health of young household members compared to male household heads (Mikalitsa 2015**).**

Second, we saw no significant association between any outcomes and household size, though studies that did (Degarege, Degarege, and Animut 2015; Degarege, Hailemeskel, and Erko 2015) also included older children in their analyses[22]—context cannot be ignored when assessing problems, and solutions.

In our panel analysis, illness in the last two months was significantly associated with negative outcomes for WHZ, wasting, WAZ, and underweight after controlling for fixed effects, which reinforces our cross-sectional findings. These results warrant both further research on responses to illness in young children in rural Ethiopia and consideration by those involved with children's health, nutrition, and related policies. The finding

[22] It is also possible that order to affect child malnutrition household sizes need to increase or decrease by a larger magnitude.

that community access to a main road was associated with positive outcomes for WHZ and underweight suggests that making rural communities more accessible may be another strategy for improving children's health and nutrition. Findings from Northwest Ethiopia by Stifel and Minten (2015) that the more remote a household, the greater the decline in household food security and U5 dietary diversity, seem to support this possibility. Finally, our finding that receipt of food aid in the last 12 months was significantly associated with positive outcomes for children who were wasted or underweight at baseline suggests that accurately targeted food aid may be an effective intervention.

With the caveat that these findings represent associations not causal relationships, we offer the following suggestions. Foremost, responses to illness in young children warrant investigation to determine what actions households and health centers take, and how these responses relate to the negative nutritional outcomes we observed. Similarly, more research is needed on the differences between male and female-headed households with regard to children's nutrition. The combination of our findings and those obtained from the proposed research could then inform nutrition-related guidelines for health centers, community health workers, and households. Main road access is also worth further investigation given its demonstrated association with improved nutritional outcomes. It is likely that increased accessibility also improves economic outcomes in rural communities and would therefore further Ethiopia's progress on related SDGs and national goals. Finally, our findings suggest that different policy approaches may be appropriate for preventing or treating undernutrition. Children undernourished at baseline were more sensitive to household changes such as asset ownership and food aid than those who were adequately nourished. Therefore, while new efforts to improve living standards may simultaneously lift undernourished children to healthier states, emphasis should also be placed on preventing undernutrition altogether, to make children more resilient to external changes.

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Tables

Table 1: Descriptive Statistics as means and (standard deviations)

	Wave 1 6-59 mo. mean (sd)	**Wave 2** 6-59 mo. mean (sd)
Outcomes		
Weight-for-height z-score	-0.321	-0.400
	(1.481)	(1.445)
Wasted	0.110	0.112
	(0.313)	(0.315)
Weight-for-age z-score	-1.277	-1.268
	(1.408)	(1.288)
Underweight	0.269	0.249
	(0.444)	(0.432)
Individual Characteristics		
Age in months	32.320	33.000
	(15.410)	(15.020)
Age in months, squared	1281.800	1314.400
	(1010.900)	(995.900)
Age in months, cubed	56664.900	57985.600
	(57683.800)	(57524.500)
Male	0.527	0.499
	(0.499)	(0.500)
Grandchild	0.058	0.047
	(0.234)	(0.211)
Father is alive	0.980	0.982
	(0.140)	(0.133)
Mother is alive	0.992	1.000
	(0.088)	0.000
Mother is literate	0.241	0.233
	(0.428)	(0.423)
Ill in last 2 months	0.213	0.248
	(0.409)	(0.432)

Table 1 (cont.): Household Characteristics

Household size	6.078	6.282
	(2.065)	(2.039)
Male household head	0.896	0.916
	(0.306)	(0.277)
Age of household head	38.450	38.570
	(11.720)	(11.050)
Dirt floor	0.978	0.977
	(0.146)	(0.149)
Solid roof	0.372	0.454
	(0.483)	(0.498)
Improved toilet	0.623	0.579
	(0.485)	(0.494)
Improved water source	0.455	0.599
	(0.498)	(0.490)
Asset Index	5.540	5.334
Descriptive Statistics as means and (standard deviations)		
	(2.537)	(2.642)
Months of food insecurity , last 12m	0.996	1.058
	(1.587)	(1.672)
Received food assistance, last 12m	0.074	0.078
	(0.262)	(0.268)
Food price shock, last 12m	0.274	0.128
	(0.446)	(0.334)
Natural disaster, last 12m	0.204	0.123
	(0.403)	(0.328)
Agricultural inputs price shock, last 12m	0.188	0.101
	(0.391)	(0.301)
Loss of livestock, last 12m	0.088	0.050
	(0.283)	(0.219)
Household member death/illness, last 12m	0.150	0.110
	(0.357)	(0.313)
Female cow ownership	0.686	0.725
	(0.464)	(0.447)
Laying hen ownership	0.472	0.465
	(0.499)	(0.499)
Milking cow ownership	0.237	0.229
	(0.425)	(0.420)

Table 1 (cont.): Community Characteristics

Main road access	0.503	0.648
	(0.500)	(0.478)
Large weekly market	0.441	0.507
	(0.497)	(0.500)
Place to buy basic medicines	0.381	0.438
	(0.486)	(0.496)
Health post	0.913	0.902
	(0.281)	(0.298)
PSNP operates in kebele	0.366	0.334
	(0.482)	(0.472)
Observations	2480	2202

Note: Observations are weighted to make results representative of all rural and small town areas in Ethiopia during Wave 1 (2012) and Wave 2 (2014).

Table 2: Linear regression results predicting weight-for-height z-score, 6-59 months (standard errors in parentheses)

	Wave 1				Wave 2			
	Individual	**Household**	**Community**	**Full Model**	**Individual**	**Household**	**Community**	**Full Model**
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Male	-0.128			-0.127	-0.083			-0.107
	(0.085)			(0.083)	(0.085)			(0.082)
Grandchild	0.037			0.276	0.220			0.101
	(0.245)			(0.272)	(0.216)			(0.221)
Mother is literate	0.190			0.105	0.108			0.042
	(0.140)			(0.145)	(0.107)			(0.109)
Ill in last 2 months	-0.208*			-0.182*	-0.171			-0.218**
	(0.113)			(0.101)	(0.108)			(0.106)
Household size		0.014		0.023		0.029		0.035
		(0.028)		(0.028)		(0.025)		(0.025)
Male household head		-0.276*		-0.234		-0.339**		-0.315**
		(0.154)		(0.153)		(0.131)		(0.142)
Age of household head		-0.008		-0.011*		-0.004		-0.006
		(0.006)		(0.006)		(0.004)		(0.004)
Dirt floor		-0.565*		-0.560*		-0.243		-0.187
		(0.320)		(0.327)		(0.216)		(0.218)
Solid roof		0.074		0.076		0.156		0.195*
		(0.121)		(0.122)		(0.115)		(0.111)
Improved toilet		-0.162		-0.159		0.202*		0.195*
		(0.129)		(0.127)		(0.114)		(0.114)

Table 2 (cont.): Linear regression results predicting weight-for-height z-score, 6-59 months (standard errors in parentheses)

Improved water source	-0.065	-0.067	-0.079	-0.075
	(0.116)	(0.120)	(0.108)	(0.107)
Asset Index	0.042	0.039	0.034	0.033
	(0.026)	(0.025)	(0.022)	(0.022)
Months of food insecurity, last 12m	-0.007	-0.011	0.041	0.045
	(0.034)	(0.034)	(0.036)	(0.035)
Received food assistance, last 12m	-0.225	-0.255	-0.073	-0.132
	(0.163)	(0.160)	(0.193)	(0.191)
Food price shock, last 12m	0.019	0.008	0.134	0.095
	(0.117)	(0.119)	(0.153)	(0.158)
Natural disaster, last 12m	0.211	0.172	-0.104	-0.017
	(0.171)	(0.154)	(0.173)	(0.175)
Agricultural inputs price shock, last 12m	0.042	0.067	-0.132	-0.104
	(0.150)	(0.154)	(0.182)	(0.168)
Loss of livestock, last 12m	-0.225	-0.220	0.121	0.156
	(0.160)	(0.158)	(0.232)	(0.225)
Household member death/illness, last 12m	-0.200	-0.181	0.066	0.102
	(0.133)	(0.132)	(0.161)	(0.161)
Female cow ownership	0.069	0.059	0.222*	0.200
	(0.118)	(0.115)	(0.135)	(0.130)
Laying hen ownership	-0.042	-0.030	0.265***	0.272***
	(0.117)	(0.117)	(0.097)	(0.094)
Milking cow ownership	0.010	0.006	-0.145	-0.145
	(0.160)	(0.157)	(0.119)	(0.121)

Table 2 (cont.): Linear regression results predicting weight-for-height z-score, 6-59 months (standard errors in parentheses)

Main road access			-0.012	-0.002			0.112	0.130
			(0.137)	(0.134)			(0.119)	(0.108)
Large weekly market			0.052	0.038			0.039	0.045
			(0.134)	(0.133)			(0.119)	(0.113)
Place to buy basic medicines			-0.036	-0.056			-0.134	-0.159
			(0.146)	(0.148)			(0.130)	(0.124)
Health post			-0.242	-0.194			-0.229	-0.295*
			(0.249)	(0.240)			(0.160)	(0.173)
PSNP operates in kebele			0.115	0.174			-0.101	-0.064
			(0.155)	(0.139)			(0.132)	(0.120)
Observations	2020	2020	2020	2020	2015	2015	2015	2015
Adjusted R2	0.008	0.019	0.003	0.025	0.029	0.054	0.030	0.063

Notes: ******* p<0.01, ****** p<0.05, ***** p<0.1. OLS regressions with standard errors (in parentheses) adjusted for clustering and stratification. Observations are weighted to be representative of all rural and small town children. All columns control for child's age in months, months squared, and months cubed.

Table 3: Linear regression results predicting wasting status, 6-59 months (standard errors in parentheses)

	Wave 1				Wave 2			
	Individual	Household	Community	Full Model	Individual	Household	Community	Full Model
	1	2	3	4	1	2	3	4
Male	0.030			0.034*	0.015			0.020
	(0.019)			(0.019)	(0.020)			(0.019)
Grandchild	-0.014			-0.057	0.024			0.068
	(0.053)			(0.062)	(0.048)			(0.055)
Mother is literate	0.006			0.022	-0.048**			-0.026
	(0.025)			(0.028)	(0.023)			(0.021)
Ill in last 2 months	0.051**			0.049**	0.030			0.037
	(0.026)			(0.025)	(0.028)			(0.026)
Household size		-0.003		-0.003		0.004		0.002
		(0.006)		(0.006)		(0.006)		(0.006)
Male household head		0.050*		0.041		0.038		0.045
		(0.028)		(0.029)		(0.030)		(0.030)
Age of household head		0.001		0.002		0.000		0.000
		(0.001)		(0.001)		(0.001)		(0.001)
Dirt floor		0.034		0.040		0.013		-0.003
		(0.034)		(0.034)		(0.049)		(0.049)
Solid roof		-0.026		-0.029		-0.049**		-0.058***
		(0.025)		(0.024)		(0.021)		(0.021)
Improved toilet		0.037		0.033		-0.039		-0.038

Table 3 (cont.): Linear regression results predicting wasting status, 6-59 months (standard errors in parentheses)

	(0.023)	(0.024)	(0.027)	(0.026)
Improved water source	-0.044*	-0.049**	-0.029	-0.026
	(0.024)	(0.024)	(0.023)	(0.023)
Asset Index	-0.006	-0.006	-0.004	-0.004
	(0.005)	(0.005)	(0.005)	(0.005)
Months of food insecurity, last 12m	0.000	0.001	-0.005	-0.006
	(0.009)	(0.009)	(0.008)	(0.007)
Received food assistance, last 12m	0.026	0.027	0.015	0.013
	(0.041)	(0.043)	(0.051)	(0.049)
Food price shock, last 12m	-0.037	-0.040	-0.081**	-0.081**
	(0.028)	(0.027)	(0.038)	(0.037)
Natural disaster, last 12m	-0.056*	-0.053*	-0.002	-0.011
	(0.030)	(0.028)	(0.036)	(0.038)
Agricultural inputs price shock, last 12m	0.030	0.029	0.047	0.043
	(0.032)	(0.034)	(0.039)	(0.035)
Loss of livestock, last 12m	0.037	0.039	-0.018	-0.028
	(0.032)	(0.030)	(0.043)	(0.041)
Household member death/illness, last 12m	0.036	0.033	-0.007	-0.013
	(0.036)	(0.036)	(0.035)	(0.035)
Female cow ownership	-0.020	-0.019	-0.050*	-0.046
	(0.025)	(0.025)	(0.029)	(0.028)
Laying hen ownership	-0.018	-0.018	-0.024	-0.022
	(0.023)	(0.023)	(0.022)	(0.021)

Table 3 (cont.): Linear regression results predicting wasting status, 6-59 months (standard errors in parentheses)

Milking cow ownership		-0.010		-0.012		0.014		0.017
		(0.027)		(0.028)		(0.028)		(0.028)
Main road access			0.008	0.007			-0.004	0.002
			(0.025)	(0.023)			(0.025)	(0.022)
Large weekly market			-0.014	-0.015			-0.040	-0.037
			(0.025)	(0.025)			(0.025)	(0.024)
Place to buy basic medicines			0.014	0.016			0.021	0.026
			(0.026)	(0.026)			(0.026)	(0.026)
Health post			0.018	0.007			0.049*	0.069**
			(0.029)	(0.028)			(0.026)	(0.032)
PSNP operates in kebele			-0.016	-0.014			0.028	0.024
			(0.028)	(0.025)			(0.026)	(0.025)
Observations	2020	2020	2020	2020	2015	2015	2015	2015
Adjusted R2	0.014	0.025	0.008	0.031	0.016	0.034	0.017	0.043

Notes:*** p<0.01, ****** p<0.05, ***** p<0.1. OLS regressions with standard errors (in parentheses) adjusted for clustering and stratification. Observations are weighted to be representative of all rural and small town children. All columns control for child's age in months, months squared, and months cubed.

Table 4: Linear regression results predicting weight-for-age z-score, 6-59 months (standard errors in parentheses)

	Wave 1				Wave 2			
	Individual	**Household**	**Community**	**Full Model**	**Individual**	**Household**	**Community**	**Full Model**
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Male	-0.226***			-0.240***	-0.103			-0.127*
	(0.067)			(0.069)	(0.069)			(0.067)
Grandchild	0.000			0.079	-0.098			0.052
	(0.145)			(0.214)	(0.140)			(0.145)
Mother is literate	0.117			0.013	0.227**			0.057
	(0.134)			(0.135)	(0.104)			(0.102)
Ill in last 2 months	-0.402***			-0.397***	-0.255***			-0.293***
	(0.111)			(0.100)	(0.091)			(0.087)
Household size		0.005		0.005		-0.019		-0.016
		(0.029)		(0.029)		(0.023)		(0.023)
Male household head		-0.260*		-0.240		-0.307**		-0.273*
		(0.149)		(0.150)		(0.138)		(0.140)
Age of household head		-0.001		-0.003		-0.011**		-0.011**
		(0.004)		(0.005)		(0.004)		(0.005)
Dirt floor		-0.100		-0.101		-0.262		-0.232
		(0.396)		(0.371)		(0.203)		(0.205)
Solid roof		0.194*		0.195*		0.184**		0.213**
		(0.106)		(0.105)		(0.089)		(0.088)
Improved toilet		-0.138		-0.119		0.093		0.087
		(0.104)		(0.099)		(0.097)		(0.097)

Table 4 (cont.): Linear regression results predicting weight-for-age z-score, 6-59 months (standard errors in parentheses)

Improved water source	0.084	0.127	0.057	0.057
	(0.104)	(0.105)	(0.095)	(0.094)
Asset Index	0.062***	0.063***	0.045***	0.043***
	(0.023)	(0.024)	(0.015)	(0.016)
Months of food insecurity, last 12m	-0.008	-0.001	0.018	0.021
	(0.035)	(0.034)	(0.031)	(0.031)
Received food assistance, last 12m	-0.144	-0.171	-0.147	-0.179
	(0.120)	(0.121)	(0.216)	(0.206)
Food price shock, last 12m	0.161	0.115	-0.069	-0.086
	(0.116)	(0.116)	(0.144)	(0.144)
Natural disaster, last 12m	0.269*	0.252	-0.209	-0.150
	(0.153)	(0.157)	(0.170)	(0.178)
Agricultural inputs price shock, last 12m	-0.057	-0.052	-0.077	-0.052
	(0.157)	(0.165)	(0.195)	(0.192)
Loss of livestock, last 12m	-0.202	-0.192	0.367*	0.380*
	(0.194)	(0.189)	(0.218)	(0.213)
Household member death/illness, last 12m	-0.212	-0.187	-0.049	-0.003
	(0.131)	(0.127)	(0.126)	(0.132)
Female cow ownership	0.288**	0.274**	0.308***	0.295***
	(0.121)	(0.121)	(0.096)	(0.097)
Laying hen ownership	-0.060	-0.059	0.198**	0.208**
	(0.105)	(0.105)	(0.090)	(0.091)

Table 4 (cont.): Linear regression results predicting weight-for-age z-score, 6-59 months (standard errors in parentheses)

Milking cow ownership		-0.034		-0.046		0.024		0.026
		(0.140)		(0.140)		(0.133)		(0.133)
Main road access			-0.081	-0.072			0.082	0.098
			(0.116)	(0.113)			(0.099)	(0.091)
Large weekly market			0.034	0.052			-0.006	-0.007
			(0.122)	(0.117)			(0.101)	(0.091)
Place to buy basic medicines			0.109	0.106			0.046	-0.021
			(0.125)	(0.119)			(0.097)	(0.092)
Health post			-0.054	0.071			-0.216*	-0.263**
			(0.243)	(0.219)			(0.116)	(0.121)
PSNP operates in kebele			0.076	0.102			-0.182*	-0.046
			(0.144)	(0.156)			(0.107)	(0.104)
Observations	2162	2162	2162	2162	2121	2121	2121	2121
Adjusted R2	0.035	0.049	0.016	0.067	0.041	0.084	0.033	0.095

**Notes: ***** p<0.01, ****** p<0.05, ***** p<0.1. OLS regressions with standard errors (in parentheses) adjusted for clustering and stratification. Observations are weighted to be representative of all rural and small town children. All columns control for child's age in months, months squared, and months cubed.

Table 5: Linear regression results predicting underweight status, 6-59 months (standard errors in parentheses)

	Wave 1				Wave 2			
	Individual	Household	Community	Full Model	Individual	Household	Community	Full Model
	1	2	3	4	1	2	3	4
Male	0.060**			0.064***	0.019			0.028
	(0.023)			(0.023)	(0.025)			(0.025)
Grandchild	-0.045			-0.130*	0.006			-0.036
	(0.057)			(0.075)	(0.054)			(0.062)
Mother is literate	-0.054			-0.016	-0.079***			-0.026
	(0.038)			(0.040)	(0.030)			(0.029)
Ill in last 2 months	0.066**			0.063**	0.071**			0.081***
	(0.032)			(0.029)	(0.031)			(0.031)
Household size		-0.002		-0.005		0.002		0.000
		(0.008)		(0.008)		(0.006)		(0.007)
Male household head		0.055		0.039		0.109***		0.093**
		(0.044)		(0.045)		(0.039)		(0.041)
Age of household head		0.002		0.003		0.003***		0.004***
		(0.001)		(0.002)		(0.001)		(0.001)
Dirt floor		-0.011		-0.018		0.066		0.061
		(0.118)		(0.115)		(0.071)		(0.072)
Solid roof		-0.063**		-0.064**		-0.073***		-0.081***
		(0.030)		(0.030)		(0.027)		(0.028)
Improved toilet		0.030		0.027		-0.025		-0.023
		(0.032)		(0.032)		(0.033)		(0.033)

Table 5 (cont.): Linear regression results predicting underweight status, 6-59 months (standard errors in parentheses)

Improved water source	-0.028	-0.035	-0.024	-0.022
	(0.033)	(0.032)	(0.030)	(0.030)
Asset Index	-0.016**	-0.014**	-0.014***	-0.014**
	(0.007)	(0.006)	(0.005)	(0.006)
Months of food insecurity, last 12m	0.005	0.003	-0.011	-0.011
	(0.011)	(0.011)	(0.009)	(0.009)
Received food assistance, last 12m	0.011	0.019	-0.007	0.000
	(0.043)	(0.044)	(0.052)	(0.049)
Food price shock, last 12m	-0.042	-0.036	0.022	0.024
	(0.034)	(0.034)	(0.046)	(0.045)
Natural disaster, last 12m	-0.086*	-0.087*	0.074	0.066
	(0.044)	(0.047)	(0.050)	(0.051)
Agricultural inputs price shock, last 12m	0.051	0.047	0.072	0.064
	(0.045)	(0.047)	(0.055)	(0.056)
Loss of livestock, last 12m	0.018	0.014	-0.070	-0.072
	(0.052)	(0.052)	(0.068)	(0.067)
Household member death/illness, last 12m	0.080*	0.078*	0.029	0.019
	(0.041)	(0.040)	(0.038)	(0.038)
Female cow ownership	-0.048	-0.044	-0.061**	-0.058**
	(0.038)	(0.038)	(0.029)	(0.030)
Laying hen ownership	-0.017	-0.018	-0.071**	-0.074**
	(0.032)	(0.033)	(0.032)	(0.031)

Table 5 (cont.): Linear regression results predicting underweight status, 6-59 months (standard errors in parentheses)

Milking cow ownership		-0.052		-0.053		-0.010		-0.009
		(0.041)		(0.042)		(0.034)		(0.034)
Main road access			-0.006	-0.007			-0.023	-0.025
			(0.037)	(0.035)			(0.028)	(0.026)
Large weekly market			-0.025	-0.028			0.003	0.001
			(0.037)	(0.035)			(0.030)	(0.027)
Place to buy basic medicines			-0.031	-0.029			-0.029	-0.008
			(0.039)	(0.036)			(0.030)	(0.029)
Health post			0.042	0.020			0.080*	0.092**
			(0.058)	(0.059)			(0.042)	(0.044)
PSNP operates in kebele			-0.017	-0.018			0.039	-0.003
			(0.045)	(0.046)			(0.032)	(0.029)
Observations	2162	2162	2162	2162	2121	2121	2121	2121
Adjusted R2	0.027	0.046	0.018	0.056	0.026	0.062	0.020	0.069

Notes:* ** p<0.01, ****** p<0.05, ***** p<0.1. OLS regressions with standard errors (in parentheses) adjusted for clustering and stratification. Observations are weighted to be representative of all rural and small town children. All columns control for child's age in months, months squared, and months cubed.

Table 6: Dynamics of wasting and underweight in Panel A

Wasting					
	Always wasted	Started wasted	Ended wasted	Never wasted	Total
%	1.92	13.02	7.07	77.99	
Observations	18	121	66	725	929
Underweight					
	Always underweight	Started underweight	Ended underweight	Never underweight	Total
%	12.23	16.18	11.29	60.3	
Observations	128	170	118	632	1048

Notes: The panel sample consists of individuals 6-41 months at baseline and 24-59 months at follow-up, and thus were 6-59 months at both baseline and follow-up. Number of observations are weighted using adjusted panel weights from ESS2. Columns are mutually exclusive.

Table 7: Fixed-effects regression results predicting a change in weight-for-height z-score for Panel A (standard errors in parentheses)

	Individual	Household	Community	Full Model
	1	2	3	4
Ill in last 2 months	-0.240			-0.294**
	(0.147)			(0.143)
Household size		-0.009		-0.025
		(0.088)		(0.084)
Age of household head		0.002		0.002
		(0.021)		(0.022)
Solid roof		-0.231		-0.177
		(0.190)		(0.201)
Improved toilet		-0.091		-0.046
		(0.108)		(0.114)
Improved water source		0.007		-0.022
		(0.157)		(0.151)
Asset Index		0.029		0.030
		(0.034)		(0.033)
Months of food insecurity, last 12m		0.005		0.008
		(0.048)		(0.046)
Received food assistance, last 12m		-0.027		-0.094
		(0.259)		(0.263)
Food price shock, last 12m		0.132		0.162
		(0.157)		(0.158)
Natural disaster, last 12m		-0.173		-0.212
		(0.241)		(0.233)
Agricultural inputs price shock, last 12m		0.188		0.171
		(0.160)		(0.165)
Loss of livestock, last 12m		0.378		0.398
		(0.290)		(0.289)
Household member death/illness, last 12m		-0.052		-0.059
		(0.213)		(0.194)
Female cow ownership		0.120		0.137
		(0.183)		(0.186)
Laying hen ownership		0.118		0.130
		(0.126)		(0.128)

Table 7 (cont.): Fixed-effects regression results predicting a change in…

Milking cow ownership		-0.284		-0.266
		(0.215)		(0.204)
Main road access			0.281*	0.278*
			(0.166)	(0.160)
Large weekly market			0.052	0.036
			(0.198)	(0.186)
Place to buy basic medicines			-0.006	-0.084
			(0.166)	(0.158)
Health post			0.110	0.089
			(0.207)	(0.198)
Observations	1994	1994	1994	1994
Adjusted R2	0.005	0.016	0.013	0.035

Notes: *** p<0.01, ** p<0.05, * p<0.1. Fixed effect regressions with standard errors (in parentheses) adjusted for clustering and stratification. Observations are weighted to be representative of all rural and small town children. The panel sample consists of individuals 6-41 months at baseline and 24-59 months at follow-up, and thus were 6-59 months at both baseline and follow-up. The set of independent variables included in each column was restricted to those variables for which at least 10% of the sample experienced a change between Waves 1 and 2. Variables excluded due to this criterion include grandchild of household head, maternal literacy, male household head, dirt floor, and PSNP presence. All columns control for child's age in months, months squared, and months cubed.

Table 7a: Fixed-effects regression results predicting a change in WHZ, by baseline status (standard errors in parentheses)

	Wasted at Baseline				Not Wasted at Baseline			
	Individual	**Household**	**Community**	**Full Model**	**Individual**	**Household**	**Community**	**Full Model**
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Ill in last 2 months	-0.603*			-0.355	-0.054			-0.096
	(0.321)			(0.326)	(0.099)			(0.109)
Household size		0.102		0.068		0.031		0.020
		(0.122)		(0.142)		(0.073)		(0.073)
Age of household head		-0.053		-0.077*		0.005		0.008
		(0.042)		(0.045)		(0.014)		(0.014)
Solid roof		1.237**		1.283**		-0.242*		-0.200
		(0.518)		(0.496)		(0.142)		(0.158)
Improved toilet		0.411		0.628		0.033		0.072
		(0.399)		(0.407)		(0.113)		(0.113)
Improved water source		0.236		0.223		-0.165		-0.185
		(0.319)		(0.298)		(0.112)		(0.116)
Asset Index		-0.065		-0.047		0.046		0.046
		(0.076)		(0.074)		(0.030)		(0.030)
Months of food insecurity, last 12m		0.090		0.096		0.011		0.013
		(0.078)		(0.076)		(0.042)		(0.041)
Received food assistance, last 12m		0.903***		0.631**		-0.301		-0.346
		(0.302)		(0.316)		(0.216)		(0.213)
Food price shock, last 12m		0.188		0.386		0.112		0.111
		(0.307)		(0.305)		(0.156)		(0.160)
Natural disaster, last 12m		-0.290		-0.406		-0.269		-0.266
		(0.261)		(0.285)		(0.216)		(0.209)

Table 7a. (cont.): Fixed-effects regression results predicting a change in WHZ, by baseline status (standard errors in parentheses)

Agricultural inputs price shock, last 12m		0.290		0.245		0.196		0.184
		(0.427)		(0.502)		(0.122)		(0.123)
Loss of livestock, last 12m		0.436		0.496		0.308		0.286
		(0.529)		(0.557)		(0.213)		(0.207)
Household member death/illness, last 12m		-1.030***		-1.120***		0.318**		0.303**
		(0.268)		(0.290)		(0.135)		(0.133)
Female cow ownership		0.129		0.093		0.027		0.039
		(0.357)		(0.371)		(0.143)		(0.147)
Laying hen ownership		-0.153		-0.079		0.134		0.143
		(0.384)		(0.366)		(0.114)		(0.116)
Milking cow ownership		-0.380		-0.243		-0.274		-0.262
		(0.320)		(0.319)		(0.196)		(0.191)
Main road access			0.170	0.384*			0.236	0.237
			(0.268)	(0.197)			(0.156)	(0.146)
Large weekly market			0.079	0.289			-0.007	-0.043
			(0.334)	(0.210)			(0.186)	(0.167)
Place to buy basic medicines			-0.265	-0.729***			0.064	-0.006
			(0.253)	(0.245)			(0.156)	(0.140)
Health post			-0.724*	0.037			0.077	0.061
			(0.364)	(0.376)			(0.195)	(0.173)
Observations	247	247	247	247	1747	1747	1747	1747
Adjusted R2	0.736	0.824	0.730	0.844	0.067	0.109	0.078	0.118

Notes: *** p<0.01, ** p<0.05, * p<0.1. Fixed effect regressions with standard errors (in parentheses) adjusted for clustering and stratification. Observations are weighted to be representative of all rural and small town children. The panel sample consists of individuals 6-41 months at baseline and 24-59 months at follow-up, and thus were 6-59 months at both baseline and follow-up. The set of independent variables included in each column was restricted to those variables for which at least 10% of the sample experienced a change between Waves 1 and 2. Variables excluded due to this criterion include grandchild of household head, maternal literacy, male household head, dirt floor, and PSNP presence. All columns control for child's age in months, months squared, and months cubed.

Table 8: Fixed-effects regression results predicting a change in wasting status for Panel A (standard errors in parentheses)

	Individual	Household	Community	Full Model
	1	2	3	4
Ill in last 2 months	0.058			0.068*
	(0.037)			(0.035)
Household size		0.009		0.012
		(0.021)		(0.020)
Age of household head		-0.004		-0.004
		(0.005)		(0.005)
Solid roof		0.133***		0.132***
		(0.049)		(0.051)
Improved toilet		0.037		0.029
		(0.033)		(0.036)
Improved water source		-0.050		-0.043
		(0.033)		(0.032)
Asset Index		-0.003		-0.003
		(0.010)		(0.010)
Months of food insecurity, last 12m		0.009		0.008
		(0.013)		(0.013)
Received food assistance, last 12m		-0.061		-0.052
		(0.054)		(0.054)
Food price shock, last 12m		-0.050		-0.062
		(0.039)		(0.039)
Natural disaster, last 12m		-0.036		-0.018
		(0.047)		(0.044)
Agricultural inputs price shock, last 12m		0.007		0.016
		(0.045)		(0.045)
Loss of livestock, last 12m		-0.042		-0.058
		(0.067)		(0.065)
Household member death/illness, last 12m		0.016		0.017
		(0.060)		(0.056)
Female cow ownership		0.029		0.026
		(0.044)		(0.044)
Laying hen ownership		-0.002		-0.009
		(0.026)		(0.027)
Milking cow ownership		0.014		0.014
		(0.049)		(0.047)
Main road access			-0.048	-0.041
			(0.038)	(0.037)
Large weekly market			-0.045	-0.034
			(0.043)	(0.039)
Place to buy basic medicines			0.053	0.065*
			(0.038)	(0.037)
Health post			-0.036	-0.009
			(0.038)	(0.039)
Observations	1994	1994	1994	1994
Adjusted R2	0.038	0.053	0.048	0.071

Notes: *** p<0.01, ** p<0.05, * p<0.1. Fixed effect regressions with standard errors (in parentheses) adjusted for clustering and stratification. Observations are weighted to be representative of all rural and small town children. The panel sample consists of individuals 6-41 months at baseline and 24-59 months at follow-up, and thus were 6-59 months at both baseline and follow-up. The set of independent variables included in each column was restricted to those variables for which at least 10% of the sample experienced a change between Waves 1 and 2. Variables excluded due to this criterion include grandchild of household head, maternal literacy, male household head, dirt floor, and PSNP presence. All columns control for child's age in months, months squared, and months cubed.

Table 8a: Fixed-effects regression results predicting a change in wasting status, by baseline status (standard errors in parentheses)

	Wasted at Baseline				Not Wasted at Baseline			
	Individual	**Household**	**Community**	**Full Model**	**Individual**	**Household**	**Community**	**Full Model**
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Ill in last 2 months	0.077			-0.027	0.014			0.021
	(0.087)			(0.084)	(0.018)			(0.020)
Household size		-0.013		0.008		-0.005		-0.005
		(0.036)		(0.045)		(0.011)		(0.010)
Age of household head		0.009		0.014		-0.006		-0.006*
		(0.010)		(0.010)		(0.004)		(0.003)
Solid roof		0.021		-0.015		0.083**		0.093**
		(0.105)		(0.101)		(0.039)		(0.040)
Improved toilet		-0.278*		-0.310*		0.000		-0.004
		(0.163)		(0.173)		(0.029)		(0.027)
Improved water source		-0.160**		-0.140*		-0.017		-0.012
		(0.080)		(0.076)		(0.025)		(0.024)
Asset Index		-0.004		0.002		-0.004		-0.004
		(0.024)		(0.022)		(0.007)		(0.006)
Months of food insecurity, last 12m		0.002		0.005		0.000		0.000
		(0.022)		(0.023)		(0.008)		(0.008)
Received food assistance, last 12m		-0.045		-0.040		-0.020		-0.020
		(0.110)		(0.143)		(0.034)		(0.032)
Food price shock, last 12m		-0.219**		-0.266***		-0.013		-0.023
		(0.090)		(0.099)		(0.032)		(0.032)
Natural disaster, last 12m		0.066		0.117		-0.012		-0.002
		(0.088)		(0.085)		(0.043)		(0.040)

Table 8a (cont.): Fixed-effects regression results predicting a change in wasting status, by baseline status (standard errors in parentheses)

Agricultural inputs price shock, last 12m		-0.121		-0.095		0.011		0.021
		(0.145)		(0.171)		(0.031)		(0.030)
Loss of livestock, last 12m		0.025		0.012		-0.018		-0.034
		(0.140)		(0.146)		(0.048)		(0.047)
Household member death/illness, last 12m		0.216**		0.271***		-0.057		-0.056
		(0.085)		(0.099)		(0.038)		(0.038)
Female cow ownership		0.176*		0.179*		0.040		0.040
		(0.090)		(0.098)		(0.031)		(0.031)
Laying hen ownership		-0.104		-0.098		0.004		-0.004
		(0.086)		(0.084)		(0.017)		(0.019)
Milking cow ownership		0.165		0.151		0.013		0.017
		(0.124)		(0.117)		(0.032)		(0.031)
Main road access			-0.055	-0.075			-0.020	-0.017
			(0.067)	(0.055)			(0.031)	(0.028)
Large weekly market			-0.058	-0.103			-0.022	-0.009
			(0.077)	(0.072)			(0.036)	(0.032)
Place to buy basic medicines			-0.059	0.123			0.058*	0.067**
			(0.094)	(0.075)			(0.030)	(0.030)
Health post			0.102	-0.015			-0.007	0.008
			(0.094)	(0.139)			(0.018)	(0.022)
Observations	247	247	247	247	1747	1747	1747	1747
Adjusted R2	0.820	0.871	0.821	0.877	0.068	0.089	0.085	0.109

Notes: *** p<0.01, ** p<0.05, * p<0.1. Fixed effect regressions with standard errors (in parentheses) adjusted for clustering and stratification. Observations are weighted to be representative of all rural and small town children. The panel sample consists of individuals 6-41 months at baseline and 24-59 months at follow-up, and thus were 6-59 months at both baseline and follow-up. The set of independent variables included in each column was restricted to those variables for which at least 10% of the sample experienced a change between Waves 1 and 2. Variables excluded due to this criterion include grandchild of household head, maternal literacy, male household head, dirt floor, and PSNP presence. All columns control for child's age in months, months squared, and months cubed.

Table 9: Fixed-effects regression results predicting a change in weight-for-age z-score for Panel A (standard errors in parentheses)

	Individual	Household	Community	Full Model
	1	2	3	4
Ill in last 2 months	-0.377***			-0.373***
	(0.118)			(0.115)
Household size		-0.063		-0.082
		(0.071)		(0.071)
Age of household head		0.006		0.007
		(0.018)		(0.017)
Solid roof		0.048		0.021
		(0.186)		(0.184)
Improved toilet		0.084		0.064
		(0.101)		(0.103)
Improved water source		-0.103		-0.124
		(0.118)		(0.118)
Asset Index		0.005		0.008
		(0.026)		(0.026)
Months of food insecurity, last 12m		0.041		0.038
		(0.039)		(0.038)
Received food assistance, last 12m		0.037		0.040
		(0.149)		(0.162)
Food price shock, last 12m		-0.208		-0.157
		(0.153)		(0.152)
Natural disaster, last 12m		0.004		-0.011
		(0.124)		(0.129)
Agricultural inputs price shock, last 12m		0.037		0.026
		(0.126)		(0.131)
Loss of livestock, last 12m		0.079		0.110
		(0.246)		(0.241)
Household member death/illness, last 12m		-0.201		-0.147
		(0.185)		(0.177)
Female cow ownership		0.279		0.273
		(0.188)		(0.185)
Laying hen ownership		-0.067		-0.043
		(0.108)		(0.109)
Milking cow ownership		-0.015		-0.018
		(0.122)		(0.121)
Main road access			0.081	0.131
			(0.095)	(0.094)
Large weekly market			-0.068	-0.066
			(0.114)	(0.113)
Place to buy basic medicines			-0.085	-0.085
			(0.115)	(0.117)
Health post			-0.093	-0.132
			(0.154)	(0.166)
Observations	2115	2115	2115	2115
Adjusted R2	0.027	0.021	0.010	0.041

Notes: *** p<0.01, ** p<0.05, * p<0.1. Fixed effect regressions with standard errors (in parentheses) adjusted for clustering and stratification. Observations are weighted to be representative of all rural and small town children. The panel sample consists of individuals 6-41 months at baseline and 24-59 months at follow-up, and thus were 6-59 months at both baseline and follow-up. The set of independent variables included in each column was restricted to those variables for which at least 10% of the sample experienced a change between Waves 1 and 2. Variables excluded due to this criterion include grandchild of household head, maternal literacy, male household head, dirt floor, and PSNP presence. All columns control for child's age in months, months squared, and months cubed.

Table 9a: Fixed-effects regression results predicting a change in WAZ, by baseline status (standard errors in parentheses)

	Underweight at Baseline				Not Underweight at Baseline			
	Individual	**Household**	**Community**	**Full Model**	**Individual**	**Household**	**Community**	**Full Model**
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Ill in last 2 months	-0.354			-0.330	-0.226**			-0.255***
	(0.290)			(0.274)	(0.094)			(0.094)
Household size		0.094		0.106		-0.032		-0.054
		(0.121)		(0.108)		(0.066)		(0.064)
Age of household head		-0.018		-0.026		0.004		0.009
		(0.051)		(0.054)		(0.016)		(0.016)
Solid roof		0.080		0.053		-0.087		-0.137
		(0.400)		(0.409)		(0.159)		(0.165)
Improved toilet		-0.147		-0.131		0.162		0.137
		(0.193)		(0.203)		(0.106)		(0.105)
Improved water source		0.069		0.046		0.029		0.017
		(0.254)		(0.250)		(0.106)		(0.108)
Asset Index		-0.037		-0.026		0.022		0.022
		(0.054)		(0.053)		(0.026)		(0.026)
Months of food insecurity, last 12m		0.117*		0.111*		0.030		0.027
		(0.065)		(0.065)		(0.035)		(0.035)
Received food assistance, last 12m		0.944**		0.735*		-0.257**		-0.215*
		(0.391)		(0.420)		(0.127)		(0.113)
Food price shock, last 12m		-0.431*		-0.296		-0.194		-0.188
		(0.251)		(0.275)		(0.118)		(0.119)
Natural disaster, last 12m		-0.143		-0.240		0.030		0.065
		(0.297)		(0.294)		(0.121)		(0.127)

Agricultural inputs price shock, last 12m		-0.122		-0.124		-0.066		-0.071
		(0.280)		(0.280)		(0.128)		(0.130)
Loss of livestock, last 12m		-0.002		-0.026		0.287*		0.295*
		(0.466)		(0.448)		(0.158)		(0.164)
Household member death/illness, last 12m		-0.528*		-0.493*		0.093		0.157
		(0.307)		(0.292)		(0.148)		(0.149)
Female cow ownership		0.072		0.051		0.258		0.265
		(0.264)		(0.243)		(0.168)		(0.165)
Laying hen ownership		0.134		0.166		-0.016		-0.009
		(0.231)		(0.229)		(0.098)		(0.097)
Milking cow ownership		-0.254		-0.167		-0.052		-0.067
		(0.332)		(0.322)		(0.115)		(0.116)
Main road access			0.166	0.172			0.085	0.114
			(0.204)	(0.204)			(0.094)	(0.090)
Large weekly market			-0.245	-0.224			-0.098	-0.124
			(0.226)	(0.265)			(0.117)	(0.123)
Place to buy basic medicines			-0.383**	-0.394*			0.053	0.047
			(0.172)	(0.200)			(0.118)	(0.114)
Health post			-0.217	0.028			-0.207	-0.261*
			(0.351)	(0.410)			(0.133)	(0.146)
Observations	594	594	594	594	1521	1521	1521	1521
Adjusted R2	0.320	0.361	0.326	0.379	0.183	0.197	0.181	0.215

Notes: *** p<0.01, ** p<0.05, * p<0.1. Fixed effect regressions with standard errors (in parentheses) adjusted for clustering and stratification. Observations are weighted to be representative of all rural and small town children. The panel sample consists of individuals 6-41 months at baseline and 24-59 months at follow-up, and thus were 6-59 months at both baseline and follow-up. The set of independent variables included in each column was restricted to those variables for which at least 10% of the sample experienced a change between Waves 1 and 2. Variables excluded due to this criterion include grandchild of household head, maternal literacy, male household head, dirt floor, and PSNP presence. All columns control for child's age in months, months squared, and months cubed.

Table 10: Fixed-effects regression results predicting a change in underweight status for Panel A (standard errors in parentheses)

	Individual	Household	Community	Full Model
	1	2	3	4
Ill in last 2 months	0.071*			0.069*
	(0.040)			(0.039)
Household size		0.011		0.018
		(0.025)		(0.025)
Age of household head		-0.004		-0.004
		(0.005)		(0.005)
Solid roof		-0.038		-0.043
		(0.065)		(0.066)
Improved toilet		-0.011		-0.013
		(0.045)		(0.043)
Improved water source		0.038		0.048
		(0.040)		(0.040)
Asset Index		0.001		0.002
		(0.009)		(0.009)
Months of food insecurity, last 12m		0.006		0.038
		(0.011)		(0.011)
Received food assistance, last 12m		-0.008		0.040
		(0.048)		(0.049)
Food price shock, last 12m		0.010		-0.157
		(0.057)		(0.056)
Natural disaster, last 12m		-0.016		-0.010
		(0.044)		(0.044)
Agricultural inputs price shock, last 12m		-0.026		0.026
		(0.056)		(0.056)
Loss of livestock, last 12m		-0.032		0.110
		(0.072)		(0.071)
Household member death/illness, last 12m		0.064		-0.147
		(0.056)		(0.055)
Female cow ownership		-0.048		-0.050
		(0.061)		(0.058)
Laying hen ownership		-0.001		-0.006
		(0.040)		(0.040)
Milking cow ownership		-0.009		-0.016
		(0.050)		(0.051)
Main road access			-0.039	-0.055*
			(0.031)	(0.029)
Large weekly market			-0.009	-0.011
			(0.042)	(0.040)
Place to buy basic medicines			-0.085	-0.009
			(0.035)	(0.036)
Health post			0.024	0.034
			(0.048)	(0.051)
Observations	2115	2115	2115	2115
Adjusted R2	0.019	0.016	0.015	0.024

Notes: *** p<0.01, ** p<0.05, * p<0.1. Fixed effect regressions with standard errors (in parentheses) adjusted for clustering and stratification. Observations are weighted to be representative of all rural and small town children. The panel sample consists of individuals 6-41 months at baseline and 24-59 months at follow-up, and thus were 6-59 months at both baseline and follow-up. The set of independent variables included in each column was restricted to those variables for which at least 10% of the sample experienced a change between Waves 1 and 2. Variables excluded due to this criterion include grandchild of household head, maternal literacy, male household head, dirt floor, and PSNP presence. All columns control for child's age in months, months squared, and months cubed.

Table 10a: Fixed-effects regression results predicting a change in underweight status, by baseline status **(standard errors in parentheses)**

	Underweight at Baseline				Not Underweight at Baseline			
	Individual	**Household**	**Community**	**Full Model**	**Individual**	**Household**	**Community**	**Full Model**
	1	**2**	**3**	**4**	**1**	**2**	**3**	**4**
Ill in last 2 months	0.061			0.016	0.011			0.009
	(0.083)			(0.096)	(0.037)			(0.032)
Household size		0.029		0.028		-0.019		-0.013
		(0.060)		(0.061)		(0.019)		(0.018)
Age of household head		-0.009		-0.009		0.002		0.001
		(0.016)		(0.017)		(0.004)		(0.004)
Solid roof		-0.097		-0.089		0.008		0.012
		(0.132)		(0.133)		(0.054)		(0.058)
Improved toilet		0.057		0.062		-0.036		-0.041
		(0.086)		(0.091)		(0.034)		(0.034)
Improved water source		0.039		0.044		-0.027		-0.009
		(0.086)		(0.090)		(0.043)		(0.046)
Asset Index		0.007		0.007		-0.001		0.000
		(0.020)		(0.020)		(0.009)		(0.009)
Months of food insecurity, last 12m		-0.022		-0.021		0.002		(0.010)
		(0.021)		(0.021)		(0.010)		(0.010)
Received food assistance, last 12m		-0.230		-0.254*		0.083		0.076
		(0.153)		(0.152)		(0.056)		(0.050)
Food price shock, last 12m		0.133		0.135		-0.033		-0.027
		(0.097)		(0.110)		(0.046)		(0.046)
Natural disaster, last 12m		0.044		0.038		-0.003		-0.007
		(0.111)		(0.108)		(0.040)		(0.040)

Agricultural inputs price shock, last 12m		0.043		0.031		0.005		0.007
		(0.107)		(0.111)		(0.060)		(0.061)
Loss of livestock, last 12m		0.018		0.024		-0.103		-0.100
		(0.091)		(0.093)		(0.067)		(0.065)
Household member death/illness, last 12m		0.130		0.115		-0.001		-0.007
		(0.097)		(0.101)		(0.051)		(0.051)
Female cow ownership		0.003		0.005		-0.033		-0.032
		(0.090)		(0.090)		(0.046)		(0.047)
Laying hen ownership		0.002		-0.005		-0.058*		-0.064**
		(0.080)		(0.081)		(0.031)		(0.031)
Milking cow ownership		0.082		0.077		0.002		-0.009
		(0.116		(0.118)		(0.053)		(0.051)
Main road access			-0.023	0.004			-0.067***	-0.074***
			(0.080)	(0.079)			(0.025)	(0.024)
Large weekly market			0.010	-0.014			0.004	0.008
			(0.094)	(0.098)			(0.036)	(0.037)
Place to buy basic medicines			-0.014	-0.036			-0.019	-0.003
			(0.062)	(0.067)			(0.031)	(0.034)
Health post			0.127	0.068			0.059	0.062
			(0.129)	(0.147)			(0.045)	(0.048)
Observations	594	594	594	594	1521	1521	1521	1521
Adjusted R2	0.390	0.405	0.388	0.401	0.176	0.193	0.193	0.209

Notes: *** p<0.01, ** p<0.05, * p<0.1. Fixed effect regressions with standard errors (in parentheses) adjusted for clustering and stratification. Observations are weighted to be representative of all rural and small town children. The panel sample consists of individuals 6-41 months at baseline and 24-59 months at follow-up, and thus were 6-59 months at both baseline and follow-up. The set of independent variables included in each column was restricted to those variables for which at least 10% of the sample experienced a change between Waves 1 and 2. Variables excluded due to this criterion include grandchild of household head, maternal literacy, male household head, dirt floor, and PSNP presence. All columns control for child's age in months, months squared, and months cubed.

Figures

Figure 1: Weight-for-age and weight-for-height z-scores, waves 1 and 2