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Small Area Estimation of Child Malnutrition in Ethiopian Woredas

Thomas Pave Sohnesen
Alemayehu Ambel
Peter Fisker
Colin Andrews
Qaiser Khan

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Abstract

Reducing child undernutrition is a key social policy objective of the Ethiopian government. Despite substantial reduction over the past decade and a half, child undernutrition is still high. With 48 percent of children stunted, underweight, or wasted, undernutrition remains an important child health challenge. The existing literature highlights that the targeting of efforts to reduce undernutrition in Ethiopia is inefficient, in part because of the lack of data and updated information. This paper remedies some of this shortfall by estimating levels of stunting and underweight in each woreda for 2014. The estimates are small area estimations based on the 2014 Demographic and Health Survey and the latest population census. It is shown that small area estimations are powerful predictors of undernutrition, even controlling for household characteristics, such as wealth and education, and hence a valuable targeting metric. The results show large variations in share of children undernourished in each region, more than between regions. The results also show that the locations with larger challenges depend on the chosen undernutrition statistic, as the share, number, and concentration of undernourished children point to vastly different locations. There is limited correlation between the shares of children underweight and stunted across woredas, indicating that different locations face different challenges.

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Small Area Estimation of Child Malnutrition in Ethiopian Woredas

Thomas Pave Sohnesen, Alemayehu Ambel,* Peter Fisker, Colin Andrews, and Qaiser Khan†

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* Corresponding authors: Thomas Pave Sohnesen tpavesohnesen@worldbank.org and Alemayehu Ambel aambel@worldbank.org

† Thomas Pave Sohnesen, World Bank and Visiting Professor with the Development Economics Research Group, University of Copenhagen; Alemayehu Ambel, World Bank; Peter Fisker, University of Copenhagen, Department of Food and Resource Economics, Changing Disasters; Colin Andrews, World Bank; and Qaiser Khan, World Bank.

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1. Introduction

Child undernutrition is an important public health problem in developing countries, as reflected by undernutrition being rated as the first priority among the world's 10 most important challenges by the Copenhagen Consensus [1]. The effect of child undernutrition could be either immediate, through increased child morbidity and mortality, or later in adult life, by affecting health and labor market outcomes. Despite considerable progress in reducing undernutrition—underweight (too low weight for age) fell from 41 to 25 percent of children, stunting (too short for age) fell from 58 to 40 percent of children, and wasting (too low weight for height) fell from 12 to 9 percent of children from 2000 to 2014 [2]—Ethiopia is still among the countries in the world with the highest child undernutrition rates. Taken together, about 48 percent of children under the age of five were undernourished (being either stunted, underweight, or wasted) in 2014, equivalent to approximately 6.3 million children [2].

The government is aware of this challenge and has set out to reduce stunting to 30 percent and wasting to 3 percent by 2015 [3]. Programs to address these challenges include: increasing agricultural productivity, promoting girls' education, immunization, integrated management of neonatal and childhood illnesses, improved access to water and sanitation, family planning, prevention of mother-to-child transmission of HIV, skilled birth delivery, and delaying of pregnancy [3].

The prevalence of different types of undernutrition differs by location in Ethiopia, indicating that different locations face different challenges [4]. International evidence also shows that many different interventions improve undernutrition outcomes, but also that similar interventions have different impacts in different settings and locations [5]. Various interventions have also been identified in Ethiopia to matter for undernutrition outcome, including: shocks and food aid [6], maternal education [7-9], ownership of selected assets such as cows [10], food availability and diversity [11-13], and access to trained and educated health professionals [14]. In line with the international evidence, the need for locally suited approaches has also been highlighted in Ethiopia [11].

Rajkumar et al. [4] evaluate the targeting of efforts to reduce undernutrition in Ethiopia and conclude, among other things, that:

1) Most nutrition-related programs focus exclusively on a subset of the country's woredas and these are difficult or impossible to identify accurately because of a poor nutrition information system.
2) Many programs use food insecurity as a proxy for nutrition insecurity, even though these are not highly correlated. Further, woreda targeting for food insecurity is often based on dated information.

They conclude: "*Ethiopia's malnutrition rate could probably be much reduced by shifting some of the programs from the woredas with a high concentration of major programs into woredas with high malnutrition*". This paper addresses this shortage of information by estimating levels of stunting and underweight for all woredas.

Levels of undernutrition often have important spatial dimensions to them. As in many other developing countries, this is also the case in Ethiopia. The urban-rural divide is large, but there are also notable variations, particularly in underweight, across regions [4]. The importance of the spatial dimension has also been observed in other countries, and the result is often strong even after controlling for other correlates. Undernutrition regressions for Vietnam, South Africa, Pakistan, and Morocco suggest that community-level efforts are of great importance [15]. Fuji [16], for instance, in his undernutrition regressions for Cambodia, finds that individual-level and household-level variables explained 20 to 30 percent of the variation in the z-score, while he was able to increase the explanatory power of the model to about 40 to 60 percent by including geographic variables and interaction terms. Alderman and Christiaensen [8] is an exception, as they find in their analysis of Ethiopia that location does not matter significantly once they control for other correlates.

Estimating levels of wasting at local levels is also desirable; however, an imputation model with reasonable accuracy for wasting was not found. Previous country studies using small area estimation (henceforth SAE) for undernutrition in Bangladesh [17], Cambodia [16,18], Ecuador, Panama, Dominican Republic [19] and Tanzania [20], were also unable to find a suitable model for wasting. Other undernutrition SAE country studies include stunting in Brazil [21]; and stunting, underweight and wasting in Nepal [22].

This paper contributes in two aspects. First, it shows that geographical targeting using woreda levels of undernutrition is a viable strategy, as it explains a large share of the variation in undernutrition levels, even after controlling for other known correlates at the household level that could be used as a targeting mechanism. Second, almost all available undernutrition studies on Ethiopia note the importance of location in identifying, understanding and addressing child undernutrition. The paper addresses this shortage of updated evidence on levels of undernutrition at the woreda level by estimating levels for 2014, using SAE.

The rest of the paper is organized as follows: Section 2 describes the data, Section 3 presents the SAE methodology, Section 4 shows the results, while Section 5 concludes.

2. Data

The primary data source of undernutrition in this study is the Ethiopia Mini Demographic and Health Survey (EMDHS) 2014 [2]. The EMDHS 2014 is a stratified nationally representative survey, including 5,579 children under five years of age. The survey follows the Demographic Health Surveys [23] standard survey design, although some sections, such as HIV and immunization, were not included. Detailed information about the sampling is available in the survey's report [2].

Undernutrition is measured as share of children moderately undernourished (below two standard deviations from the mean) based on z-scores for stunting (height for age), underweight (weight for age) and wasting (weight for height). The z-scores were calculated using EMDHS and the 2006 WHO growth standards [24].

To obtain estimates of undernutrition rates at the woreda level, EMDHS is combined, through SAE, with the 2007 Census. The 2007 census has two formats – a long and a short format. The long format is richer in terms of data and, in addition to demographic information, it includes information on assets, housing characteristics, education, fertility, and mortality. A randomly selected 20 percent of the households received the long form, while the other 80 percent received the short form that only covered basic demographics.

The EMDHS and a 10 percent sample of the 2007 census are available on request from the Central Statistical Agency [25].

3. Small Area Estimation Methodology

Woreda level estimates of undernutrition are estimated by SAE. In essence, the methodology constructs a prediction model between the z-score and observable household and location characteristics in EMDHS. This model is then used to predict a z-score for every child using the census. This paper relies on the SAE method developed in Elbers, Lanjouw, and Lanjouw [26] , known as the ELL methodology. This method, in particular, is attractive, as it is both the most applied method and it can be implemented in the freeware program PovMap.

First, a set of variables deemed to be similarly defined and distributed in the survey and the census are identified. Utilizing only these variables ensures that the estimated z-scores from the model pertain to 2014 (the year of the survey) and not 2007 (the year of the census).

Second, a z-score model is constructed in the survey data:

$$z_i = X_{ih}^{survey}\beta + Z'\gamma + u_{ih} \qquad (1)$$

where X_{ih}' is the vector of explanatory variables for child *i* in household *h*, β is the vector of coefficients, Z' is the vector of location specific variables, γ is the vector of coefficients, and u_{ih} is the error term due to the discrepancy between the imputed z-score and the actual value. X_{ih}' is child and household level variables that have similar definitions and distributions in survey and census, while Z' includes location-specific averages or other transformations of variables found in the census that cannot be found in the survey, and external variables, such as geo-spatial variables that can be added to both the survey and the census.

Third, undernutrition estimates and their standard errors are computed via simulations using the estimation model. There are two sources of errors involved in the estimation process: errors in the estimated regression coefficients ($\hat{\beta}$, $\hat{\gamma}$) and the disturbance terms, both of which affect undernutrition estimates and the level of their accuracy. In ELL, a simulated z-score is calculated for each census child by a predicted z-score as in (2):

$$z_i = X_{ih}^{census}\beta + Z'\gamma + u_{ih} \qquad (2)$$

These simulations are repeated a large number of times (100 in the case of this application), with new values for β, γ, and u_{ih} drawn from their distributions, in each repetition. The distributions of β, γ are obtained through GLS, while the distribution of u_{ih} is obtained through a non-parametric approximation following Elbers and van der Weide [27]. All the estimation is automated within the PovMap program.

For any given location (such as a woreda), each simulation is used to calculate the share of children underweight or stunted (a z-score below negative two standard deviations). The mean across the simulations of an undernutrition statistic provides a point estimate of the statistic, and the standard deviation provides an estimate of the standard error.

In most applications of ELL, the error term u_{ih} is decomposed into two independent components: $u_{ih} = \eta_c + \varepsilon_{ih}$, where η_c is a cluster-specific effect and ε_{ih} an individual effect. In this application, the error term has not been split into a cluster and individual effect, as no cluster effect was found. The lack of a cluster effect is likely closely related to the sampling design of EMDHS, as it is designed with few EAs within each region and relatively large samples within each EA.

Application of SAE to Ethiopian data

SAE estimates of stunting and underweight is done at woreda level. Woreda is the third administration layer after region and zone. Each woreda is also divided into kebeles, which are the smallest administrative units in Ethiopia. A woreda on average has around 12,000 children, with a standard deviation of 8,000, with around 2,000 children at the 5 percentile and 28,500 children at the 95 percentile. The estimates are based on regional z-score models. Regional models have the advantage of fitting data relevant to local circumstances, although they limit the number of variables in each model as the number of observations decreases. No models were established for Harari, Dire Dawa, and Addis Ababa, as all woredas (or equivalent locations) were sampled in the survey. For those areas, the sample from EMDHS 2014 is used.

The Ethiopian census has both a short and a long form, and to increase model fit, the models use the long form, including enumeration area (EA) averages of all variables from the census whether found in the survey or not. Separate models for the long and short form are theoretically possible. Unfortunately, this is not possible using the PovMap software, as the program cannot handle the likely correlation between two such models, which would result in inaccurate estimates of undernutrition standard errors.

To mitigate issues arising from the time interval between the 2007 Population Census and EMDHS 2014, only variables whose distributions did not change much between the two are used in the z-score models. A detailed examination of the distribution of all variables found in both survey and census ensured that only similar variables were utilized in the models. Appendix Table A1 shows the survey and census means for variables included in the models. All models include variables that are based on EA or higher-level census means; these are not included in Table A1, as they are comparable by definition.

Variable selection into the estimation models was based on contribution to adjusted r-square, but also considered variable skewness (very skewed variables were excluded as it could result in overfitting to the sample) and correlation between variables (highly correlated variables were excluded). Further, all models include variables generated at levels above the household level, as too high spatial correlation in the error term relative to overall error term can jeopardize accuracy of estimated standard of error of undernutrition indicators [28,29]. The models also include variables as number of children in household and children close in range, which capture within household correlation. See also Jones and Haslett [22], as well as Fujii [16], for alternative ad hoc modeling solutions for within household correlation.

The models have adjusted r-squares similar to those of other undernutrition regressions, particular those used for undernutrition maps (0.06 to 0.27 for stunting and between 0.08 and 0.14 for underweight). Some studies have succeeded in developing undernutrition models for SAEs of undernutrition with R-squares as high as 0.6 and 0.7 [16]. However, some express concern for overfitting with R-squares above 0.35 [21]. The full regional regression models are enclosed in appendix Table A2.

As a check on model accuracy, Table 1 shows the model-imputed undernutrition rates and those measured in EMDHS at regional level. The table shows that measured undernutrition rates in EMDHS and the estimated rates from census are similar, and none of the estimates are outside the 95 percent confidence interval of the measured levels.

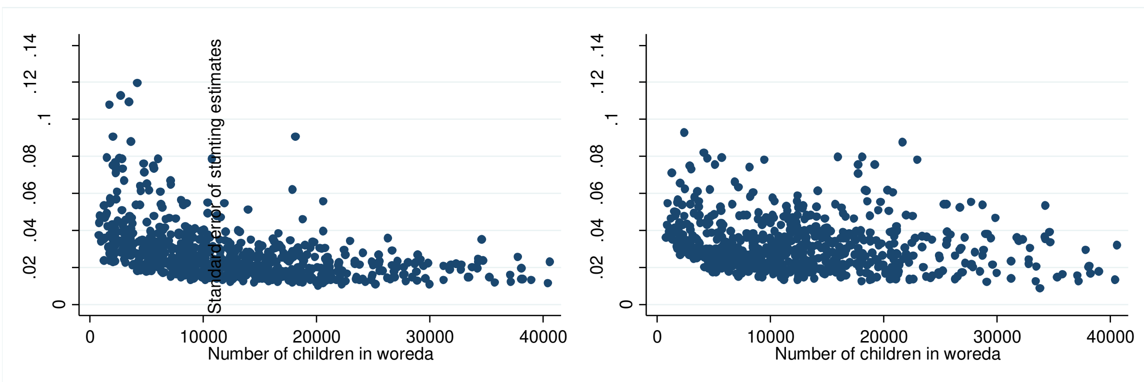
Table 1. Measured and imputed undernutrition rates, 2014

	Region	Imputed undernutrition rate	Survey undernutrition rate	95 % confidence interval for survey estimates		Observations in survey
Stunting	Tigray	0.440	0.459	0.380	0.537	435
	Afar	0.404	0.465	0.396	0.533	565
	Amhara	0.413	0.432	0.376	0.488	518
	Oromia	0.410	0.385	0.334	0.435	635
	Somali	0.420	0.360	0.292	0.427	565
	B. Gumuz	0.412	0.406	0.353	0.459	426
	SNNP	0.421	0.443	0.391	0.496	673
	Gambela	0.275	0.219	0.149	0.288	403
Underweight	Tigray	0.351	0.312	0.262	0.364	445
	Afar	0.496	0.455	0.408	0.514	608
	Amhara	0.341	0.291	0.248	0.343	523
	Oromia	0.271	0.229	0.196	0.286	656
	Somali	0.403	0.386	0.331	0.460	591
	B. Gumuz	0.327	0.282	0.212	0.364	438
	SNNP	0.289	0.260	0.213	0.325	699
	Gambela	0.224	0.199	0.126	0.273	412

Source: DHS 2014 and imputed values from models.

SAE has great potential to guide policy decisions to address undernutrition, as they provide a much- improved information base, allowing better targeting. However, as also illustrated in Table 1, both measures from surveys and the estimates from our models come with standard errors. The estimated standard errors of undernutrition levels across woredas are on average similar and a little larger than those observed at regional levels from the survey. Woredas with smaller populations of children generally come with larger standard errors. Figure 1 illustrates the standard errors in relation to the number of children in each woreda. It illustrates both how woredas with lower number of children have larger standard errors (the left tail), and how standard errors are larger for stunting than underweight. Standard errors for stunting are slightly larger than for underweight (despite stunting models having higher r-square) due to larger underlying variation in z-scores for stunting than for underweight. As example of the influence of standard errors: 65 percent of woredas have underweight levels above the national average of 26.6, while only 41 percent of these are significantly above the national average (based on the woreda estimates lower bound of the 95 percent confidence interval being above the national mean). Similarly, 46 percent of woredas have stunting levels that are above the national average, while only 14 percent are significantly above that level (again using the 95 percent confidence interval).

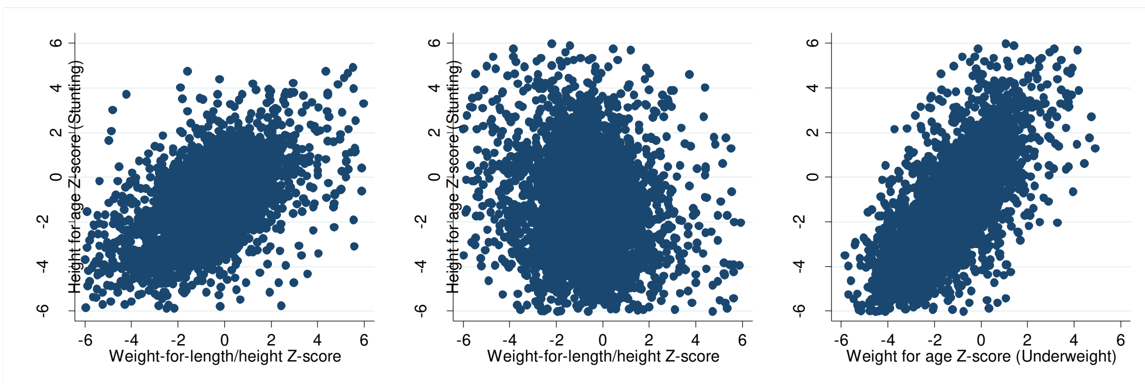
Fig 1. Standard errors of underweight and stunting rates, and number of children in woredas.



4. Results

From an undernutrition point of view, many would argue that stunting and wasting are indicators of different types of undernutrition. They have a different etiology, different causes, and different consequences. Underweight, on the other hand, can be seen as a composite indicator of the two, reflecting either both or one of the two. As mentioned above, it has not been possible to contribute with SAEs of wasting; however, wasting has data commonality with underweight as both indicators rely on children's weight (underweight related to height and wasting related to age). Hence, wasting and underweight could be correlated, and if highly correlated, underweight could proxy wasting. A priori, a high correlation between underweight and wasting should not be expected as estimation models for both were based on same available data, and only in the case of underweight, a satisfying model was found. Nevertheless, wasting and underweight have a significant pairwise correlation of 0.52 in the 2014 EMHDS survey. Figure 2 illustrates, in a scatter diagram, the partial correlation with notable noise between underweight and wasting. As such, one can consider underweight a proxy, albeit an imperfect proxy, for wasting. Stunting, on the other hand, has no correlation to wasting, while there is a high correlation between underweight and stunting (Figure 2).

Fig 2. Z-score correlation between underweight and wasting, and stunting and wasting



Are woredas a useful targeting mechanism?

As pointed out in the introduction, existing literature points to weaknesses in data for geographical targeting, and our estimates fill a current data gap. However, is woreda targeting using SAE the most efficient targeting mechanism? Given available data, a complete analysis of this question is not possible, but woreda targeting can be compared to some other alternatives. A data-driven national targeting strategy requires data for the entire nation that is correlated with undernutrition. The profile of undernutrition, based on correlates is well-documented [9,14,30] and useful, as some of these can be used as targeting instruments, and some can even be argued to have a causal relationship. Some of these might be more efficient targeting instruments as they can be observed locally and do not require a full household survey and imputation models. For instance, access to health facilities could be argued to have a causal impact and could, potentially, be used as a targeting mechanism. Traveling distance to the nearest health facility would be one option (see, for instance, Schmidt and Kedir [31] who estimate travel distance to nearest major urban area in Ethiopia, using GIS data). Access to food as proxied through wealth is another example, as is mothers' education. The two latter examples are not great targeting metrics, as you need to observe each household, but due to their consistent high correlation to undernutrition, they are also included to gauge the SAE results merits.

To investigate if imputed woreda levels of stunting and underweight are a useful targeting metric, an OLS regression of z-scores is estimated in the EMDHS with addition of the SAE estimates. The regression includes the following potential targeting metrics as control variables: a) access to health services approximated by households utilizing any pre- or post-natal services [32], as physical access to health care could be used as a targeting mechanism through GIS analysis of traveling distance; b) access to clean water approximated through households utilizing protected water source; c) lack of access to toilet facilities; d) access to food and other necessities, and or knowledge approximated by wealth measured by the EMDHS asset index; and e)mothers' education. Note that the alternative targeting mechanisms are allowed to vary for each household, which should give them a comparative advantage in correlation to the z-score, compared to imputed undernutrition levels at woreda level, which are averages across thousands of children.

Use of protected water sources, lack of access to toilet facilities, utilization of health services for both stunting (in height for age regressions) and underweight (in weight for age regressions) have the expected signs, with lack of access to toilets and access to health facilities being significantly related to the z-score (column 1 and 5, Table 2). Controlling for wealth and mothers' education, however, render these variables insignificant with only wealth and mothers' education remaining significant (columns 2,3,6 and 7, Table 2). Similar patterns have been observed in Ethiopia before, based on other data sets [30]. SAE results in addition to these variables are highly significant, indicating that additional information is found in the estimated undernutrition levels at the woreda level that cannot be found in the already included alternative targeting metrics at the household level. Further, when the estimated woreda levels of stunting and underweight are included in the household level regression, the r-square almost doubles (column 4 and 8, Table 2). Hence, undernutrition levels at the *woreda level* explain a relatively large share of the variation in z-scores, even controlling for other *household level* proxies, and would seem like a valuable targeting metric in addressing stunting and underweight.

Table 2. OLS regression of z-scores targeting alternatives

	Height for Age				Weight for Age			
Column	1	2	3	4	5	6	7	8
Dependent variable: z-score	HAZ	HAZ	HAZ	HAZ	WAZ	WAZ	WAZ	WAZ
Potential targeting variables								
HH has access to protected water	0.05	-0.05	-0.04	-0.04	0.07	-0.01	-0.02	-0.00
	(0.10)	(0.11)	(0.12)	(0.11)	(0.07)	(0.07)	(0.08)	(0.06)
HH has no access to toilet	-0.16*	-0.02	-0.04	-0.09	-0.13*	-0.02	-0.03	-0.01
	(0.09)	(0.10)	(0.11)	(0.10)	(0.06)	(0.07)	(0.07)	(0.07)
HH utilize health service	0.15*	0.06	-0.02	-0.01	0.13*	0.05	0.00	0.03
	(0.09)	(0.09)	(0.09)	(0.10)	(0.07)	(0.07)	(0.08)	(0.07)
Wealth		0.00***	0.00**	0.00		0.00***	0.00	0.00
		(0.00)	(0.00)	(0.00)		(0.00)	(0.00)	(0.00)
Mothers' education (no education is the excluded category)								
Primary			0.18*	0.16*			0.23***	0.16*
			(0.10)	(0.09)			(0.08)	(0.08)
Secondary			0.62**	0.57**			0.68***	0.62***
			(0.24)	(0.25)			(0.15)	(0.14)
Tertiary			1.14***	1.06***			0.93***	0.95***
			(0.31)	(0.32)			(0.35)	(0.33)
Imputed woreda stunting/underweight level				-3.15***				-3.42***
				(0.45)				(0.42)
Constant	-1.52***	-1.40***	-1.48***	-0.19	-1.27***	-1.17***	-1.29***	-0.27*
	(0.08)	(0.08)	(0.09)	(0.20)	(0.07)	(0.07)	(0.07)	(0.15)
Number of observations	4,220	4,220	3,838	3,838	4,372	4,372	3,976	3,976
R2	0.004	0.012	0.018	0.034	0.006	0.015	0.025	0.052

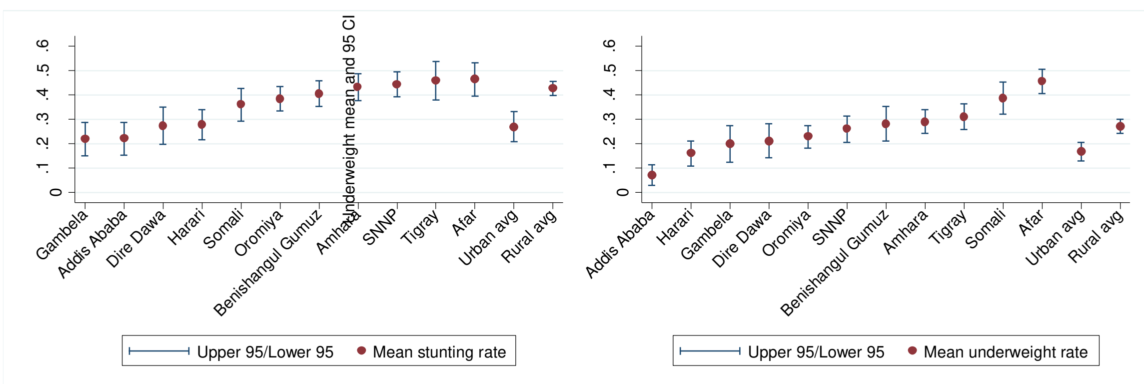
The asterisks indicate the significance level: *** p<0.01, ** p<0.05, * p<0.1. Standard errors in parentheses. Regressions take sample design and household weights into account by using Stata's svy command. Data: EMDHS 2014.

Note that access to water and toilet and education are also potential variables (as EA averages) in the imputation models, and the z-score was, of course, used to obtain the SAE estimates in the first place. However, for the purposes of the analysis above, these dependencies are not a concern.

Woreda estimates of undernutrition

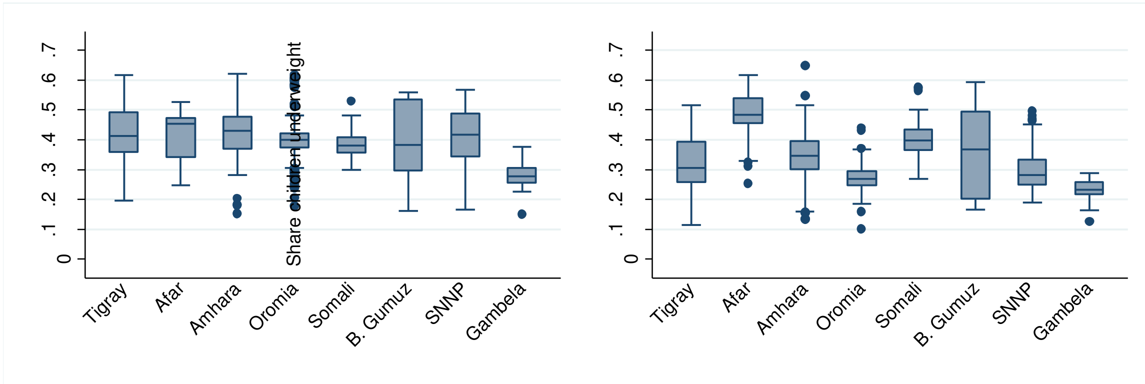
Before presenting the SAE results, Figure 3 shows stunting and underweight at the regional level based on EMDHS. Figure 3 shows that the urban-rural divide is an important indicator of undernutrition levels. Child stunting is 16 percentage points higher in urban (27.0%) than rural (42.6%) areas. The urban divide is also reflected in regional variation with urban-dominated regions as Addis Ababa, Dire Dawa, Harari, and Gambella (regions sorted by share of population living in urban areas) having significantly lower rates of stunting, compared to other regions. For underweight, regional differences are smaller, though the south and eastern regions Afar and Somali have significantly higher underweight rates, while capital Addis Ababa has significantly lower rates (Figure 3). Though stunting and underweight levels vary across regions, many are not significantly different from each other, as observed by the 95 percent confidence intervals (Figure 3).

Fig 3. Share of children stunted and underweight with 95 percent confidence intervals by region.



A first observation, based on the SAE-obtained woreda level estimates, is that only a few regions are cohesive with similar levels of undernutrition across woredas (Figure 4). Most regions are not cohesive and have large variations in levels of underweight and stunting across woredas. This is illustrated in Figure 4 by the wide ranges of levels across woredas within each region. In almost all regions, woredas with higher levels have more than twice the level of those with lower levels. Though the variation in number of woredas in each region influences the graph (from a low of 13 in Gambella to a high of 277 in Oromia), it indicates that there is scope for spatial targeting within most regions.

Fig 4. Variation in share of children stunted in each woreda across regions



Legend: The bar in center of box is the median underweight rate across woredas in each region. The box is the 25th and 75 percentile; dots are outside values.

The share of children undernourished is likely the most common way of showing the spatial distribution of the undernourished. Figures 5 and 6 illustrate this in image A for stunting and underweight, respectively. Woredas further away from the center of the country tend to have higher levels than woredas closer to the center (with some notable variation). Some of these areas, like the dry areas in Somali (to the southeast) have a relatively small population, and, as such, the absolute number of undernourished children is relatively low, as illustrated in image B of Figures 5 and 6, where each dot represent 100 stunted or underweight children. Image B illustrate that most stunted or underweight children often live close to the center of the country. Further, more urban areas, though having a relative low share of undernourished children (Figure 3), have a large population, and a large population that is spatially very concentrated. This concentration is illustrated by the image D in Figures 5 and 6 where the difference in height shows how the number of children per km2 is very high in some urban centers. Finally image C shows both the number and share of underweight and stunted children (Figure 5 and 6). Figures 5 and 6 are not meant to argue for or against any targeting strategy, but merely illustrate that the kind of lens utilized (share, number, or number of children per km2) colors the perception of where the challenges are largest. Further, some of these tradeoffs might also impact the kind of strategy chosen to address undernutrition in different locations in Ethiopia. Figures 7 and 8 show explicitly how the different targeting lenses (share, number and number per km2) correlate, reinforcing the impression from Figures 5 and 6 that, in most instances, woredas with larger undernutrition challenges depend on the statistic considered.

Fig 5. Share, number and concentration of underweight children in woredas

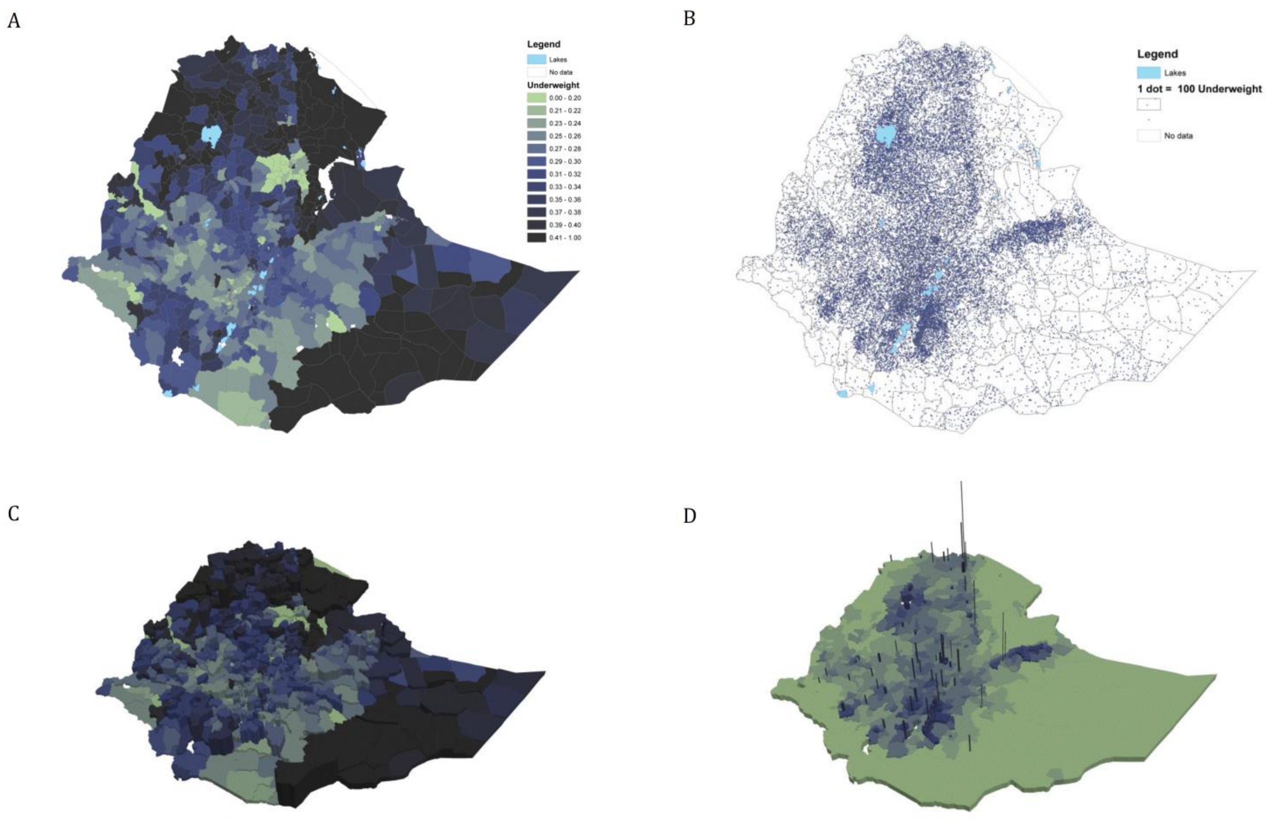


Fig 6. Share, number and concentration of stunted children in woredas

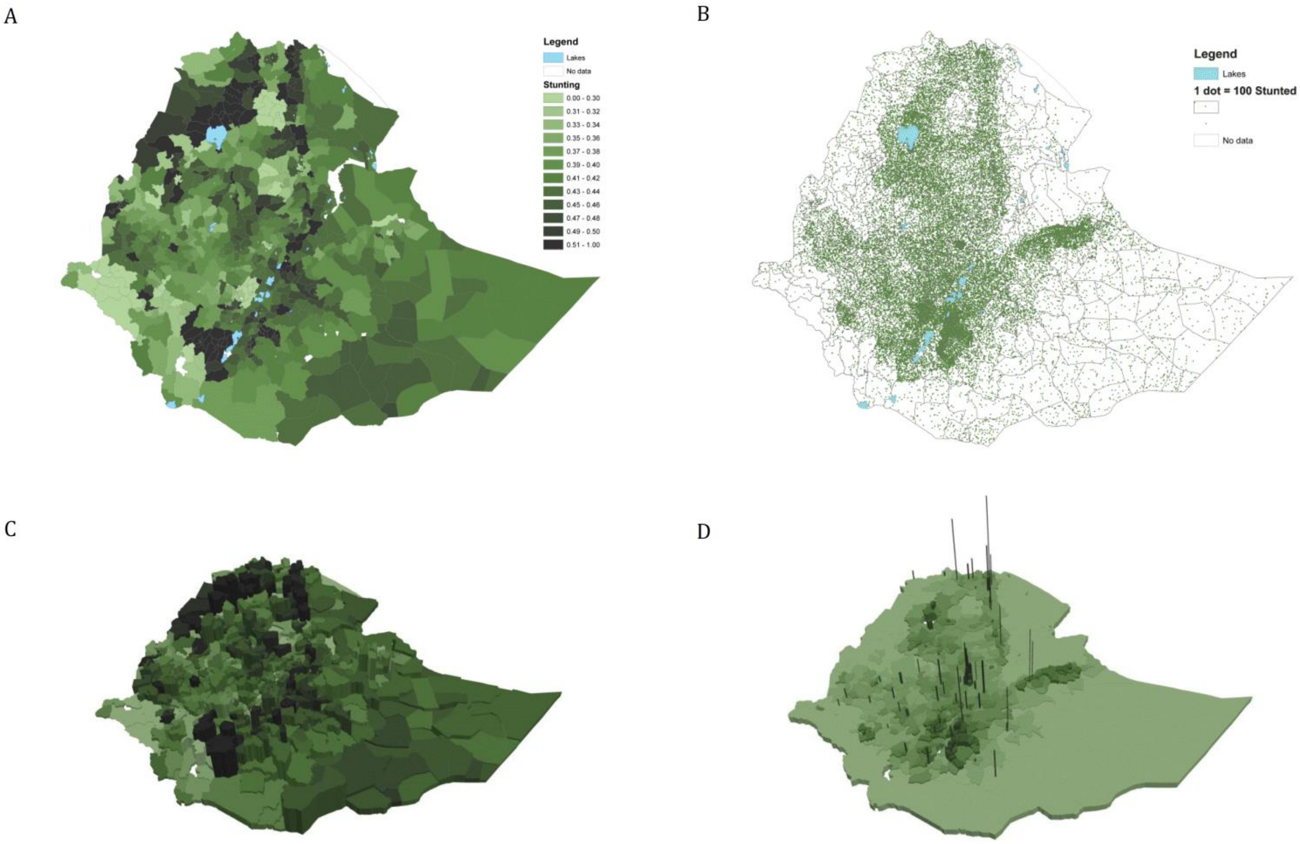


Figure 7. Spatial correlation between share, number and concentration of stunted children

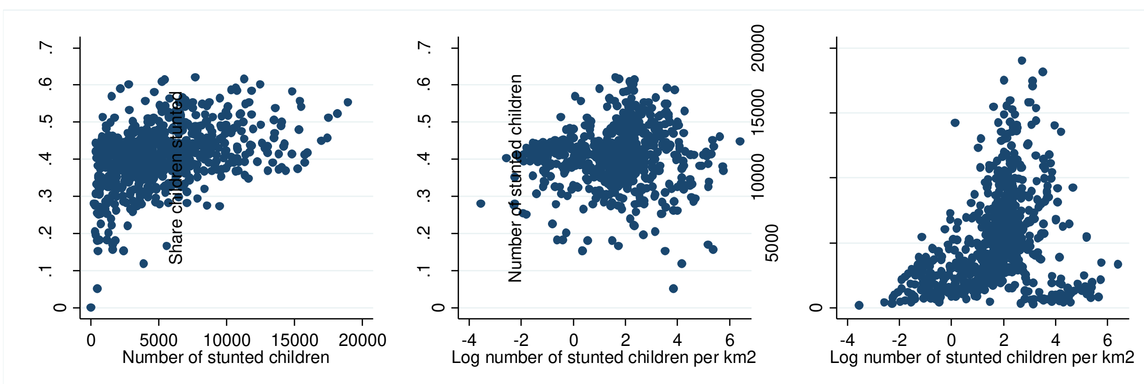
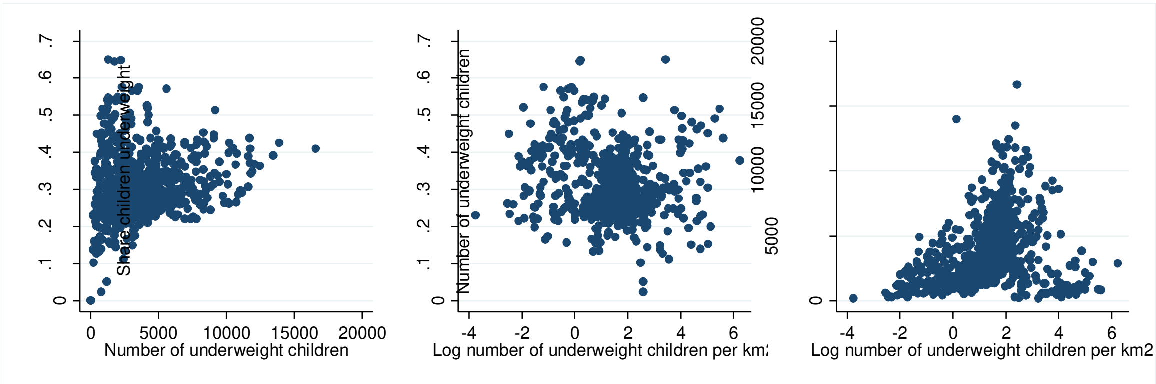


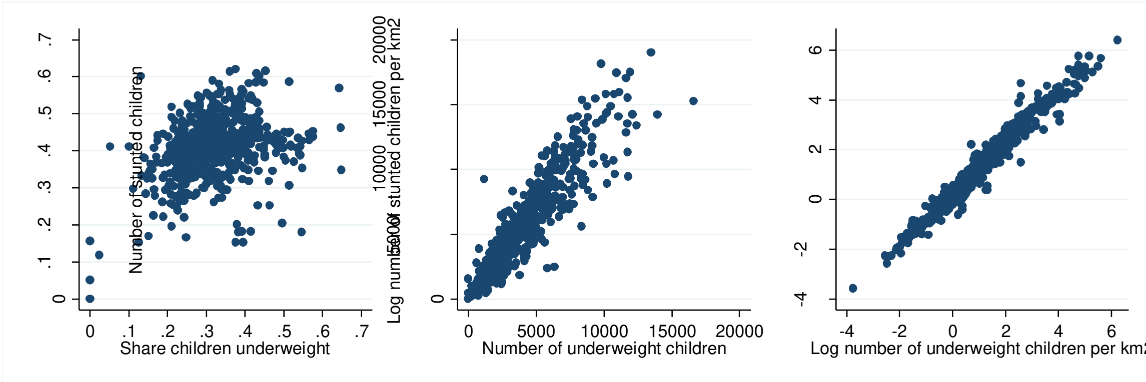
Figure 8. Spatial correlation between share, number and concentration of underweight children



Aiming to reduce undernutrition, it would be advantageous if underweight and stunted children are spatially located in the same areas. In Figure 2, it was shown that at child level z-scores for stunting and underweight are positively correlated, but what about levels of underweight and stunting spatially? Figure 9 shows that the correlation between the shares of children stunted and underweight is noisy (image to the left). However, the correlation between numbers of children underweight and stunted (image in the center), and numbers of underweight and stunted per km2 (images to the right), are highly correlated.

Hence, if interventions can benefit from the concentration of children, underweight and stunting can be addressed in the same locations, while less so if the share of children is more important. Though these graphs do hint that there can be a tradeoff between targeting the share of children as opposed to the concentration of children, the graphs are not evidence of such a tradeoff, nor do they provide direct guidance on how best to address undernutrition. Finding 5,000 families most likely to foster stunted children among 50,000 in an urban setting might or might not be harder than finding similar 50 families among 100 in a rural setting. They might, however, provide guidance on which instruments to use to address undernutrition.

Fig 9. Location of underweight and stunted children



5. Concluding Remarks

This paper contributes the first estimates of child undernutrition at the woreda level in Ethiopia. It shows that SAE of undernutrition seems like a good and useful data-driven metric for targeting undernutrition. The results provide an opportunity to reassess whether current efforts are as effective as they can be and where there might be need for new or additional efforts. The results also point to notable variation within some regions and limited correlation between areas with high shares of children underweight and stunted, indicating that local context matters, a result echoed in the literature on undernutrition in Ethiopia. This, combined with the high spatial concentration of undernourished children in some locations, could provide insights as to different types of undernutrition interventions and future ways to address undernutrition.

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32. A dummy variable taking the value 1 if the mother has visited a health clinic during pregnancy, given birth at a health clinic or received a post-natal visit by a health worker. The dummy is defined based on available questions on health facility use, related to pregnancy

Appendices

Table A1. Mean of variables in survey and census

	Tigray		Afar		Amhara		Oromiya		Somali		B. Gumuz		SNNP		Gambela	
	surv	cens	surv	cens	surv	cens	surv	cens	surv	cens	surv	cens	surv	cens	surv	cens
Child age = 0	**0.17**	**0.19**	0.19	0.10	0.18	0.18	**0.18**	**0.17**	0.16	0.07	0.19	0.17	0.17	0.16	0.16	0.15
Child age = 1			**0.15**	**0.15**	**0.18**	**0.19**	**0.16**	**0.19**	**0.18**	**0.14**	**0.20**	**0.19**	**0.16**	**0.18**	**0.15**	**0.18**
Child age = 2			**0.24**	**0.23**	**0.19**	**0.20**	**0.19**	**0.22**	**0.22**	**0.26**	**0.21**	**0.22**	**0.19**	**0.20**	**0.18**	**0.21**
Child age = 3	**0.21**	**0.21**	**0.22**	**0.22**	**0.23**	**0.20**			**0.22**	**0.19**	**0.19**	**0.19**	**0.24**	**0.22**	**0.25**	**0.23**
Child age = 4	**0.22**	**0.21**	**0.21**	**0.30**	**0.22**	**0.22**	**0.22**	**0.24**	**0.22**	**0.34**	**0.21**	**0.22**	**0.23**	**0.24**	**0.25**	**0.23**
Gender: female	**1.46**	**1.50**			1.50	1.50										
No. of HH members = 4															0.20	0.19
No. of Small children = 1	0.35	0.39														
No. of Small children = 2							0.47	0.47								
No. of young = 1			**0.09**	**0.08**					**0.17**	**0.20**						
No. of young = 3					**0.24**	**0.26**										
No. of young = 4			0.22	0.23											0.21	0.22
No. of adults = 3					**0.18**	**0.20**										
No. of adults = 4															0.09	0.09
Male HH head													**0.89**	**0.85**		
Age of HH head															**37.9**	**36.0**
Spouse in HH					0.88	0.89										
Rural									**0.62**	**0.88**					**0.80**	**0.77**
Water source: Public tap							**0.15**	**0.16**								
Roof material: Thatch													0.67	0.67	**0.64**	**0.68**

Notes: Values in **bold** are for variables used in the height-for-age- model; values that are underlined are for variables used in the weight-for-age model.

Table A2: Regression models

Tigray height-for-age

	Coef.	SE	P
Child age 0	1.810	0.19	0.000
Child age 4	0.296	0.17	0.077
EA avg. age of HH head	-0.070	0.02	0.000
EA avg. Floor material: mud	1.460	0.55	0.008
EA avg. Male HH head	-2.312	0.67	0.001
EA avg. Number of rooms: 1	0.952	0.29	0.001
EA avg. Self employed	0.379	0.23	0.095
Gender: female	0.230	0.14	0.092
Zone = 2	0.790	0.18	0.000
Constant	0.235	0.80	0.768
Obs. in census	107,107		
Obs. in survey	435		

R^2	0.261
Adj. R^2	0.245

Afar height-for-age

	Coef.	SE	P
Child age 1	-1.75	0.38	0.00
Child age 2	-1.75	0.34	0.00
Child age 3	-1.66	0.35	0.00
Child age 4	-1.60	0.34	0.00
EA avg. Light source: Firewood	1.15	0.38	0.00
EA avg. Orphans	-7.47	1.87	0.00
No small children in HH= 1	2.43	1.15	0.03
Constant	0.15	0.29	0.61
Obs. in census	26,089		
Obs. in survey	565		
R^2	0.133		
Adj. R^2	0.122		

Amhara height-for-age

	Coef.	SE	P
Child age 1	-1.235	0.20	0.000
Child age 2	-1.252	0.20	0.000
Child age 3	-1.127	0.19	0.000
Child age 4	-1.217	0.19	0.000
EA avg. Water source: public tap	1.098	0.4	0.006
EA avg. Water source: unprotected spring	1.218	0.26	0.000
EA avg. Children age 5-10 enrolled in school	-3.289	0.86	0.000
EA avg. House age less than 10 years	-1.992	0.61	0.001
Number of adults: 3	0.275	0.15	0.067
Number of Young: 3	0.223	0.14	0.107
Zone = 2	0.822	0.26	0.002
Zone = 3	0.491	0.23	0.034
Zone = 4	1.207	0.27	0.000
Zone = 5	0.545	0.38	0.148
Zone = 6	0.828	0.23	0.000
Zone = 7	0.929	0.25	0.000
Zone = 8	1.492	0.77	0.052
Zone = 9	0.851	0.28	0.002
Zone = 10	0.844	0.32	0.009
Constant	-0.994	0.30	0.001
Obs. in census	419,466		

Obs. in survey	518
R^2	0.203
Adj. R^2	0.173

Oromiya height-for-age

	Coef.	SE	P
Child age 0	2.66	0.19	0.00
Child age 1	0.83	0.20	0.00
Child age 4	0.61	0.17	0.00
Water source: public tap	-0.63	0.22	0.00
EA avg. Cooking fuel is dung	-0.67	0.18	0.00
EA avg. Number of disabled	-3.45	1.71	0.04
EA avg. House age less than 5 years	-1.23	0.34	0.00
EA avg. Houses with livestock	1.04	0.48	0.03
EA avg. Share has employment	4.27	1.28	0.00
Constant	-2.35	0.47	0.00
Obs. in census	734,674		
Obs. in survey	635		
R^2	0.267		
Adj. R^2	0.256		

Somali weight-for-age

	Coef.	SE	P
Child age 1	-2.04	0.35	0.00
Child age 2	-2.15	0.34	0.00
Child age 3	-2.46	0.34	0.00
Child age 4	-2.38	0.34	0.00
EA avg. Water source: river	-0.63	0.26	0.01
EA avg. Water source: unprotected spring	-0.34	0.24	0.16
Number young in HH:3	-0.53	0.27	0.05
Rural	-0.32	0.23	0.16
Constant	1.33	0.35	0.00
Obs. in census	75,249		
Obs. in survey	591		
R^2	0.169		
Adj. R^2	0.158		

B. Gumuz height-for-age

	Coef	SE	P
Child age 1	-0.86	0.38	0.02
Child age 2	-1.37	0.36	0.00

Child age 3	-1.22	0.37	0.00
Child age 4	-1.45	0.36	0.00
EA avg. Young HH member	-7.42	1.42	0.00
EA avg. House age less than 10 years	4.94	0.84	0.00
EA avg. HH has livestock	2.18	0.40	0.00
EA avg. Number of rooms: 1	1.37	0.36	0.00
EA avg. Share employed	1.61	0.77	0.04
Constant	1.95	1.32	0.14
Obs. in census	21,542		
Obs. in survey	425		
R^2	0.186		
Adj. R^2	0.168		

SNNP height-for-age

	Coef.	SE	P
Child age 1	-1.594	0.26	0.000
Child age 2	-1.729	0.25	0.000
Child age 3	-2.142	0.23	0.000
Child age 4	-2.030	0.23	0.000
EA avg. House age less than 15 years	2.481	0.68	0.000
EA avg. HH has radio	1.201	0.39	0.002
Male HH head	-0.496	0.24	0.038
Zone = 2	0.701	0.32	0.029
Zone = 4	0.229	0.21	0.265
Zone = 6	0.459	0.32	0.153
Zone = 7	1.276	0.47	0.007
Zone = 9	1.236	0.34	0.000
Zone = 11	1.091	0.29	0.000
Zone = 17	0.866	0.47	0.066
Zone = 20	0.928	0.38	0.014
Zone = 21	1.710	0.62	0.006
Constant	-0.676	0.36	0.061
Obs. in census	402,868		
Obs. in survey	673		
R^2	0.213		
Adj. R^2	0.192		

Gambela height-for-age

	Coef.	SE	P
Child age 1	-0.838	0.39	0.034
Child age 2	-1.506	0.37	0.000
Child age 3	-1.718	0.34	0.000

Child age 4	-1.106	0.34	0.001
Age of HH head	0.020	0.01	0.019
EA avg. Government employed	2.013	0.57	0.001
Rural	-0.715	0.37	0.052
Roof material: Thatch	0.732	0.32	0.023
Constant	-0.617	0.53	0.250
Obs. in census	7,148		
Obs. in survey	403		
R^2	0.198		
Adj. R^2	0.178		

Tigray weight-for-age

	Coef.t	SE	P
Child age 0	0.42	0.14	3.02
EA avg. Ceiling quality	1.61	0.56	2.88
EA avg.Heating kerosene	-2.13	0.46	-4.61
EA avg. First grade	-7.48	2.02	-3.71
EA avg. Male head	-1.23	0.40	-3.09
EA avg. Number of rooms: 2	-0.64	0.30	-2.15
EA avg. Share adults employed	-0.85	0.35	-2.43
Constant	0.19	0.36	0.54
Obs. in census	107,107		
Obs. in survey	445		
R^2	0.127		
Adj. R^2	0.112		

Afar weight-for-age

	Coefficient	SE	P
Child age 0	-0.38	0.21	-1.79
Child age 2	-0.69	0.19	-3.59
Child age 3	-0.54	0.20	-2.73
EA avg. Garbage burnt	-0.74	0.22	-3.41
EA avg. First grade	4.05	2.28	1.77
EA avg. House age less than 10 years	-1.64	0.68	-2.40
EA avg. Number of dead children	1.65	0.38	4.29
Kebele avg. Public tab	-1.19	0.39	-3.07
Number of young: 4	-0.56	0.18	-3.12
Constant	-1.36	0.18	-7.69
Obs. in census	26,089		
Obs. in survey	608		
R^2	0.117		

Adj. R^2	0.104

Amhara weight-for-age

	Coef.	SE	P
Child age 0	0.618	0.12	0.000
EA avg. HH has Ceiling	3.607	1.56	0.021
EA avg. Water source: Unprotected spring	0.621	0.16	0.000
EA avg. Children age 5-10 enrolled in school	-1.839	0.53	0.001
EA avg. Light source: Electricity	-2.197	0.74	0.003
EA avg. Number of rooms	0.450	0.10	0.000
EA avg. Religion: Muslim	0.895	0.16	0.000
Gender: female	-0.157	0.09	0.078
Number of Young: 3	0.329	0.10	0.002
Spouse in HH	-0.352	0.16	0.025
Constant	-2.127	0.22	0.000
Obs. in census	419,466		
Obs. in survey	523		
R^2	0.157		
Adj. R^2	0.140		

Oromiya weight-for-age

	Coef.	SE	P
Child age 0	1.063	0.14	0.000
EA avg. Cooking fuel: Dung	-0.372	0.14	0.006
EA avg. Cooking fuel: fire	-0.555	0.26	0.032
EA avg. Floor material: Mud	-3.424	0.78	0.000
EA avg. House age less than 20 years	0.881	0.38	0.019
EA avg. Livestock lives in HH	2.073	0.42	0.000
EA avg. Orphan HH member	3.958	1.76	0.025
Number of small children: 2	-0.232	0.11	0.029
Constant	0.695	0.59	0.237
Obs. in census	734,674		
Obs. in survey	656		
R^2	0.135		
Adj. R^2	0.124		

Somali weight-for-age

	Coef.	SE	P
Child age 0	1.682	0.21	0.000
EA avg. Cooking fuel: Other	-0.981	0.36	0.007
EA avg. Light source: Lantern	0.534	0.24	0.025

EA avg. Roof material: Thatch	-0.900	0.25	0.000
EA avg. Wall material: Wood or Mud	-1.256	0.27	0.000
Constant	-0.759	0.25	0.003
Obs. in census	75,249		
Obs. in survey	591		
R^2	0.173		
Adj. R^2	0.166		

B. Gumuz weight-for-age

	Coef.	SE	P
Child age 0	0.98	0.22	0.00
EA avg. Migrant HH	-6.66	2.45	0.01
EA avg. Number of orphants	-13.09	2.44	0.00
EA avg. Enrollment third grade	-6.23	1.65	0.00
EA avg: Has employment	10.51	2.23	0.00
EA avg. Roof material: Thatch	1.77	0.34	0.00
EA avg. Waste disposal burned	-2.03	0.38	0.00
EA avg. Wall material: wood and mud	1.52	0.24	0.00
Constant	-2.24	0.41	0.00
Obs. in census	21,542		
Obs. in survey	437		
R^2	0.253		
Adj. R^2	0.239		

SNNP weight-for-age

	Coef.	SE	P
Child age 0	0.688	0.15	0.000
Child age 4	-0.437	0.13	0.001
EA avg. House age less than 15 years	3.359	0.60	0.000
EA avg. House age less than 20 years	-3.556	0.91	0.000
EA avg. Kitchen outside	-1.201	0.35	0.001
EA avg. Light source: firewood	5.156	0.98	0.000
EA avg. Male head of HH	-1.179	0.51	0.021
EA avg. Number of rooms: 2	-0.456	0.21	0.028
EA avg. House ownership	0.665	0.29	0.022
EA avg. Education level: Third grade	2.493	0.76	0.001
Roof material: Thatch	-0.254	0.12	0.031
Constant	-0.927	0.50	0.066
Obs. in census	402,868		
Obs. in survey	699		

R^2	0.168
Adj. R^2	0.154

Gambela weight-for-age

	Coef.	SE	P
Child age 0	0.373	0.21	0.074
EA avg. Water source: unprotected spring	0.533	0.32	0.098
EA avg. Government employed	1.248	0.38	0.001
Number of HH members: 4	-0.688	0.26	0.008
Number of adults: 4	-0.504	0.25	0.046
Number of young: 4	-0.330	0.19	0.078
Rural	-0.366	0.23	0.117
Constant	-0.727	0.23	0.002
Obs. in census	7,148		
Obs. in survey	401		
R^2	0.112		
Adj. R^2	0.096		