FACTORS ASSOCIATED WITH STUNTING IN ETHIOPIAN CHILDREN UNDER FIVE

ENGINE: Empowering New Generations to Improve Nutrition and Economic opportunities
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Factors associated with stunting in Ethiopian children under five

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Executive Summary

Background

Over a third of all deaths of children under the age of five are directly or indirectly caused by undernutrition (1, 2). Growth faltering often begins*in utero*and is indicated by a low birth weight.Height-for-age frequently drops from birth to ~ 24 months of age and usually does not recover thereafter (3, 4). Most malnourished childrenaged 3 to 5 years already had anthropometric deficits in height at the end of their first year of life, a pattern that is consistent across different developing countries. Interventions through this period - labeled as the 'window of opportunity'- target exclusive breast-feeding and optimal complementary feeding practices, which are crucial in the prevention of malnutrition and the observed growth faltering (1, 3, 4).

Ethiopia suffers high rates of both infant mortality (52 per 1000) and malnutrition in infants and young children, contributing to an estimated 270,000 deaths per year, or one-third of all deaths inunder-five children(5). Good nutrition promotes adequate childhood growth, cognitive development and resistance to infection. Severe and/or repeated attacks of childhood malnutrition will decrease physical and mental development. Preventing malnutrition and illness prevents deaths, and ensures that children grow and lead healthy, productive lives(6, 7). There is strong evidence that the prevention of malnutrition in infants and children requires access and intake of nutritious food during pregnancy and exclusive breastfeeding for the first 6 months of life; breastfeeding combined with appropriate complementary foods starting at 6 months of age followed by good feeding practices through 24 months of age; access to clean drinking water and sanitation;and access to preventive, prenatal, and curative health care (8, 9). This report details our analysis of factors, which contribute to stunting in Ethiopia using three recent DHS surveys.

The 2000 and 2005 DHS surveys highlighted the challenge of childhood malnutrition in Ethiopia. Since then, the Government of Ethiopia has emphasized good nutrition practices through health education, treatment of extremely malnourished children and provision of micronutrients to mothers and children. The Health Extension Programme (HEP) includes nutrition within the basic health service package.A national nutrition strategy and program has been implemented as well(5). Thus significant progress has been made and the 2011 DHS documents a marked decline in the rates of childhood stunting and underweight in the last 11 years. Nonetheless 44% of Ethiopian children aged 6-24 months are still stunted, varying by region (5). Additional progress can be seen in the high rate of breast feeding with 52% of under 6 month olds being exclusively breast fed. Challenges still exist within the complementary feeding period with manyfoods not being introduced in a timely fashion and only 4% of children aged 6-23 months being fed an appropriately diverse diet. Maternal health services have improved,yet in the past five years, only19% of women havefour or more antenatal visits and only 10% of births were attended by a skilled provider. Infant and young child health services have also improved yet only 24% children are fully vaccinated. While levels of respiratory morbidity are low (7% of children showed symptoms of an acute respiratory infection, ARI, in the two weeks before the survey), 17% of children under five had

had a fever and 13% had had diarrhea. This set of analyses is intended to further identify factors linked to stunting in Ethiopia.

Approach and Findings

This study aims to examinerisk factors for stunting in Ethiopian children using DHS data from 2011, and to examine the trends, variability, and changes in thesefactors over timeusing the 2000 and 2005 DHS.Regional and socioeconomic strata differences are also analyzed. Data for three DHS surveys (DHS 2000, 2005 and 2011) were downloaded, cleaned and merged for analyses. The analyses used a conceptual framework that categorizes factors affecting height for age in infants and young children as being inherent, distal, intermediate and proximate in nature (10). This is similar to the UNICEF conceptual framework framing the basic, underlying and immediate causes of poor maternal, infant and young child nutrition. Descriptive statistics (including means, standard deviations, frequencies), Pearson correlations, and odds ratios were estimated. Step-wise multivariate linear and logistic regressions were then conducted. The majority of analyses were focused on identifying statistically significant associations with stunting outcomes in individual children. A subset of analyses examined the associations between specific foods, and of sanitation, with stunting by region.

Stunting in Infants and Children

The onset of stunting is visible by 6-12 months of age and increases to ~ 24 months of age in all three DHS surveys. In infants <6 months of age, stunting rates have significantly decreased, going from 22% (2000) and 23% (2005) to 14% in 2011. Stunting rates for children aged 6-24 months went from 49% in 2000, to 47% in 2005,to 35% in 2011. For children under five, ratessimilarly declined significantly from 54% in 2000, to 49% in 2005, and to 41% in 2011. The DHS 2011 data revealed that stunting rates are over 40% in Affar, Amhara, Tigray, and Benishangul-Gumu, with the highest rates in Tigray (52%). Rates in Oromiya, SNNPR, Dire Dawa, Gambela, Harar and Somali region range from 21-32% while Addis Ababa had the lowest rate (13%).

In the 2011 DHS survey, using a stepwise logistic regression analysis after adjustment for the effects of distal factors, we find that the factors associated with stunting include the child's age, male gender, low household wealth, low maternal education, shorter birth interval, smaller birth size, lower maternal height, low maternal BMI and having had diarrhea in the past 2 weeks. Of note, the strongest effects/associations were with wealth. Infants and young children were 2.2 times more likely to be stunted if born to mothers in the poorest households rather than the richest households. Infants and children reported to have had a very small birth size were twice as likely to be stunted as those who were very large at birth. Girls were 25% less likely to be stunted then boys. For every unit increase in BMI, andmaternal height (1 cm.), children were 3% and 6%, respectively, less likely to be stunted.

Risk factors associated with stunting differed by child age group. This may be because the risk factors require time to adversely impact a child or become biologically relevant at different times during early childhood. Only maternal height was a significant predictor of the risk of being stunted in infants under 6 months of age. Every 1 cm unit increase in maternal height wasassociated to aneight percent risk reduction for stunting.For children aged 6-12 months, increasing age, male sex (gender), and short maternal height were significant predictors as well as low birth weight. Dietary diversity was protective against stunting and persistent breastfeeding beyond 6 months of age was linked to stunting. Predictive factors in the final multivariate model for the age group 12-24 months included age, being a boy, wealth index, maternal education ($p > 0.05$), birth size, maternal heightand still being breastfed. Similar to the 6-12 month age group, age, being a boy, very small birth size and shorter maternal height were significantly associated with the risk of being stunted. Finally in children greater than 24 months of age, in addition to the factors seen in the 12-24 month age group, stunting was also associated with shorter birth interval, lower maternal BMI, having had a diarrheal episode and having had a fever within two weeks prior to the survey.

Comparing trends, across years, shows several common risk factors associated with stunting. A summary of the key findings is presented in Table 1. In 2005, similar to 2011, factors associated with stunting included age, male gender, shorter birth interval, smaller birth size, shorter maternal height and having diarrhea in the past two weeks. In addition, cough in the past 2 weeks, or still being breast-fed were all associated with stunting in the final model. Specifically the strongest associations were with birth size with (respectively) very small size babies and average babies being 1.5 and 1.3 times more likely to be stunted than the reference group, very large babies. Children who had diarrhea in the past two weeks were 1.4 times more likely to be stunted. Infants were 10% less likely to be stunted for every 1 cm unit increase in maternal height.Other factors includedcough in the past two weeks (20% less likelihood of being stunted) as well as still being breastfed (2.8 times more likely to be stunted). In 2000, significant factors included age, sex, education, having no latrine, birth interval, birth size, having had a polio vaccine, maternal height, diarrhea in the past 2 weeks, number of antenatal visits, and still being breast fed. The strongest associations were found with maternal education, birth interval, birth size, maternal height, and diarrhea within the past 2 weeks. Smaller than average, and very small, babies were 1.8 and 1.6 times, respectively, more likely to be stunted than very large babies; 1 cm of additional maternal height decreased the risk of stunting by 5%; and having had diarrhea in the past 2 weeks increased the risk of stunting by 1.3 fold. Common predictors of stunting forall 3survey years included age, male gender, lower birth interval, lower birth size and maternal height, while the factors associated with stunting that were unique to 2011 included maternal BMI, and if food was given in the first 3 days of life and low wealth index.

Table 1: Summary findings of final step wise model for years 2000, 2005 and 2011

Factors included in final model	Significant Predictors*		
	2011 n=5275	2005 n=3225	2000 n=5043
Age (months)	X	X	X
Sex of child			
Female			
Male	X	X	X
Maternal Education			
None			X
Primary			X
Secondary			X
Higher	Ref	Ref	Ref
Wealth Index			NA
Poorest	X		
Poorer	X		
Middle	X		
Richer	X		
Richest	Ref		
No household latrine			X
Birth interval (months)	X	X	X
Birth size			
Very small	X	X	X
Smaller than average			X
Average		X	
Larger than average			
Very large	Ref	Ref	Ref
Maternal height (cm)	X	X	X
Polio vaccine reported/on card			X
Measles vaccine reported/on card	X		
Maternal BMI	X		
Diarrhea in last 2 weeks	X	X	X
Cough in last 2 weeks		X	
Fever in last 2 weeks	X		
Number of antenatal visits	X		X
Gave food other than breast milk w/in first 3 days	X		NA
Still breastfeeding	X	X	X

X= significant predictor, $p<0.05$
Ref= Reference value for the regression
NA= Data not available for that year

Linear regression analyses were used to examine the relationship betweenmean height for age Z-scores with key risk factors across the three survey years. Factors that were associated with mean HAZ score were similar across the three years. Specifically in 2005, diarrhea in past two weeks was associated with a lower mean HAZ score while in the 2000 analysis, maternal BMI was positively associated with HAZ score and presence of an improved latrine (pit latrine with or without slab and all other forms of improved latrines) was significantly and positively associated with HAZ score. The latter was not significant in any of the other survey years. In all of the above models, the 'explanatory power' of the models ranged between an R^2 of 0.14 and 0.23, e.g. could explain between 14 and 23% of the stunting seen in individual infants and children. A key point to be made here is that the statistical analysis was conducted at the individual level, that is the factors that are associated to the individual risk of being stunted.

Analyses were also conducted to examine variation in dietary pattern by region and by risk of being stunted. A frequency analyses shows that a large majority of Ethiopian infants and young children consumed grains, roots and/or tubers (71%). Other food groups were much less common, dairy being the next most consumed (30%). Dairy and the consumption of 'other' (non-green leafy, vitamin A rich) fruits and vegetables were both protective against stunting (OR=0.72 and 0.47, respectively). Consumption of grains roots and/or tubers, or legumes, was positively associated with stunting(OR=1.52 and 1.35, respectively). While dairy was the most common animal source food it was consumed in low amounts in Tigray, Amhara and Bishangul-Gumuz (10-20% of children). In most regions, less than 2.5 meals and less than twofood groups were consumed by infants aged 6-24 months. Regions with higher mean dairy consumption were more likely to have less stunting. *Of note, the consumption of dairy* alone *explained ~ 27% of the stunting variation between regions (R^2 = 0.2672).* Stunted children were likely to have been reported as consuming more meat but the association was not significant..

A key factor associated with stunting in recent literature has been exposure to open defecation. This can be imputed by the lack of a latrine and the lack of improved water and sanitation facilities. Work by Spears (2013), for example, has suggested that half or more of the variance in height in children can be explained by a lack of sanitation[16]. Lack of sanitation operates at multiple levels, including the individual, the household, and the community. For example, a household with a latrine surrounded by a community without latrines is still exposed environmentally to the effects of the lack of sanitation. A series of analyses (similar to that reported by Spears) were thus conducted to examine the association of water and sanitation variables at the regional level with the risk of being stunted. Because these variables are known to also be predictive of diarrheal disease, which is a significant factor in the analyses, biological plausibility is clearly present. There are some associations at the individual level with improved facilities in Addis Ababa, Amhara, Somali region and Affar however the analysis is limited by small sample sizes in each region.

However, our regional analysis of relationship between open defecation and risk of being stunted shows that *open defecation alone can explain 29% (R^2 = 0.29) of the variation in stunting by region*. In amultivariate model, which started with open defecation and then included factors in a stepwise fashion, *the addition of first of wealth index and then of maternal heightmarkedly increased the explanatory power to 71% of the variationat the regional level (R^2 = 0.71)*. However, this statistically reduced the *individual* predictive significanceof having a latrine(p>0.05). Thus there is an effect of lack of latrine or an improved latrine is stronger as described by the high R-square when examining data at an aggregate (in this case region) level.

Similarly the presence of improved latrine was significantly associated with a reduced risk of stunting, and the significance was retained when maternal height was added to the model however was lost when wealth index was added into the model. These indicate to us that these factors are related in ways which require data beyond that available in the DHS surveys and require analyzing information not just at the household level but also at the community/district/region environmental level. The effects of lack of sanitation at a community wide level clearly need to be considered. For example, while wealthier households may have more hygienic habits or infrastructure, or be clustered in residential areas where latrines are more common, they may still exist within a larger environment/catchment area that is exposed high levels of unhygienic behavior and/or infrastructure thus diluting the statisticallyidentifiable beneficial effects of improved sanitationat the household level as might be expected by the presence of an improved latrine.

We conclude that the individual predictors of stunting across children under five years of age include age, male sex (gender), low wealth index, low birth size, low maternal education (in older children), low maternal height, low maternal BMI and the presence of diarrhea in the preceding two weeks. Common individual predictors of stunting among all three survey years included age, male sex, low maternal education, short birth interval, small birth size and lower maternal height, while the factors associated with stunting that were unique to 2011 included low maternal BMI and low wealth.

There is good evidence that dietary patterns and practices (in younger age groups), and the presence or absence of good water and sanitation practices and facilities, influence stunting. These latter factors operate at the regional level as well as at the household level. Our interpretationsare constrained due to regional level sample size restrictions. Having said that, the consumption of dairy products, and of fruits and vegetables, appeared to decrease the risk of stunting, while the consumption of grains roots and/or tubers, and of legumes, was linked to an increased risk of stunting. The absence of sanitation was strongly predictive of stunting by itself and in combination with maternal height and wealth index, was strongly indicative of stunting at the regional level. The magnitude of explanatory power of the dietary and sanitary factors strongly suggests that they should be investigated in greater depth given the limitations of DHS data.

Introduction

Over a third of all deaths of children under the age of five are directly or indirectly caused by undernutrition (1, 2). Growth faltering begins immediately after birth with height for age dropping sharply from birth to 24 months to almost 3 years of age and not recovering thereafter (3, 4) with most of those malnourished at ages 3 to 5 already presenting anthropometric deficits in height at the end of the first year of life, a pattern that is consistent across different developing countries. Interventions through this period labeled as the window of opportunity targeting exclusive breast-feeding and optimal complementary feeding practices are considered crucial in the prevention of malnutrition and the observed growth faltering (1, 3, 4).

Ethiopia suffers high rates of both infant mortality (52 per 1000) and malnutrition in infants and young children, contributing to an estimated 270,000 deaths, or one-third of all deaths of under-five children each year (5). Good nutrition is essential for adequate growth and cognitive development of children as well as for their ability to resist and fight infection. Severe and repeated attacks of malnutrition during childhood can negatively impact the physical and mental development of children. Preventing malnutrition among children is an important step in reducing illness and death and ensures that children grow and lead healthy, productive lives (6, 7). Growth faltering begins immediately after birth with height for age dropping sharply from birth to 24 months to almost 3 years of age and not recovering thereafter (3, 4). Most of those malnourished at ages 3 to 5 already present anthropometric deficits in height at the end of the first year of life, a pattern that is consistent across different developing countries.

The 2005 DHS survey highlighted the high rates of stunting, wasting and underweight in Ethiopia(11). Since then, the Government of Ethiopia has accelerated its efforts to enhance good nutrition practices through health education, treatment of extremely malnourished children and provision of micronutrients to mothers and children. The Health Extension Programme (HEP) now incorporates nutrition within the basic health service package and a national nutrition strategy and program has been developed and implemented by the Government of Ethiopia (5). Thus significant progress has been made and the current DHS reports a marked decline in proportion of children stunted and underweight in the last 11 years, high rates of breast feeding with 52% of under 6 month olds being exclusively breast fed. Issues still exist within the complementary feeding period with foods not being introduced in a timely fashion and only 4% of children aged 6-23 months being fed appropriately. Maternal health services including antenatal care coverage has improved but only 19% of women made four or more antenatal visits with only 10% of births in the past five years being delivered by a skilled provider. Infant and young child health services have improved yet only 24% children are fully vaccinated. While levels of respiratory morbidity are low (7% of children showed symptoms of ARI in the two weeks before the survey), 17% of children under five had a fever and 13% had diarrhea. Furthermore 44% of Ethiopian children between the ages of 6 to 24 months are still stunted, with estimates varying by region (5).

Prevention of malnutrition in infants and children requires access and intake of nutritious food starting at birth with exclusive breastfeeding for the first 6 months of life, breastfeeding in combination with complementary foods from 6-24 months of age, access to clean drinking water and sanitation, access to preventive and curative health care (including prenatal) (8, 9). As such, interventions through this period—known as the "window of opportunity"—targeting exclusive breast-feeding and optimal complementary feeding practices are considered crucial in the prevention of malnutrition and the observed growth faltering (1, 3, 4). This study aims to examine the risk factors associated with stunting using DHS data from 2011 as well as compare the trends and changes in risk factors associated with stunting in Ethiopian children across different years (DHS 2000, 2005 and 2011).

Study Rationale and Aim

Reviewing the literature, one finds considerable variability in the factors that affect stunting in Ethiopian children. Furthermore while the rates of stunting have reduced from DHS 2005 to DHS 2011, it is important to understand what the trends in these changes are with respect to the different regions, different socio-economic strata, differences in rates/Z-scores due to differences in type of area (e.g. rural versus urban, food surplus versus food deficit). The overall aim of this study are toexamine the risk factors associated with stunting using DHS data from 2011 as well as compare the trends and changes in risk factors associated with stunting in Ethiopian children across different years (DHS 2000, 2005 and 2011). This will be examined using the hierarchical framework outlined in Wamani et al(10).

Study Objectives

The objectives of the study are:

1. To examine the trends and variability in stunting across different years, regions and socio-economic strata
2. To identify the factors associated with stunting using the DHS 2011 data
3. To compare the current risk factors with those associated with stunting in the prior data (DHS 2011, 2005 and 2000)

Methods

Based on literature sources (Ethiopia and global), a list of factors were created using the Wamani et al classification(10). Table 2 provides the list of variables by the level of association (proximate, inherent and distal). Figure 1 provides a graphical representation of how the factors (inherent, distal, intermediate and proximate) are likely to be associated with stunting in Ethiopian children. Thus all analyses were conducted giving consideration to the factors and the level at which they occur.

Table 2: List of factors identified as being associated with stunting in literature

Inherent factors • Age • Sex	Distal factors • Household socio-economic status • Mothers education • Father's education • Household asset/wealth index • Household land ownership • Household expenditures • Household income
Intermediate factors • Presence of a latrine, • Presence of improved latrine • Access to clean water (e.g. presence of a tap • Water treatment • Maternal age, • Birth order • Birth size (or weight) • Deworming and immunization status	Proximal factors • Use of pre-lacteal feed • Mothers' health status and use of prenatal care • Breast feeding status, • Infant and young child feeding indicators (minimum number of meals, dietary diversity, minimum number of food groups etc), • Age of introduction of complementary foods, • Morbidity (fever, acute respiratory infections, cough and diarrhea)

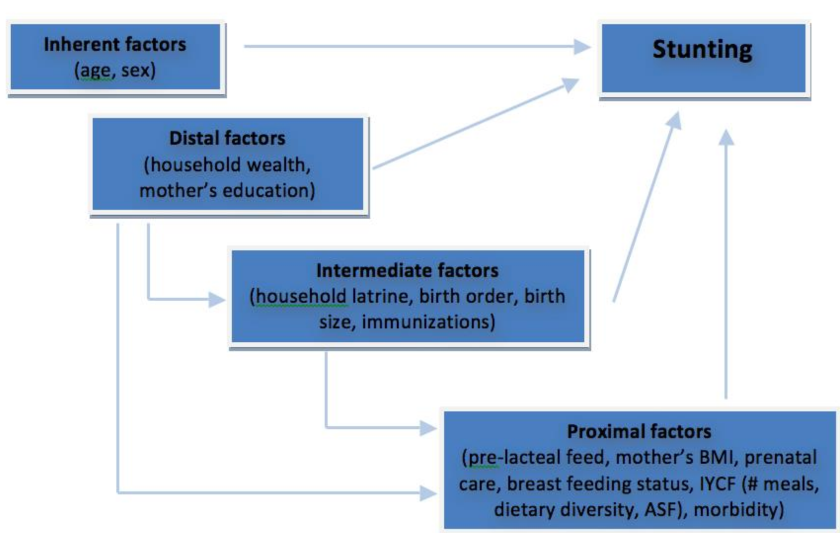


Figure 1: Conceptual hierarchical framework

Data handling

The data for each DHS year comes in multiple datasets for individuals (mothers infants, children) and household characteristics, etc. Relevant data sets that included the variables of interest were downloaded. These include Child_ETKR41FL, women_ETIR41FL, household_ETHR41FL for the year 2000, childeren_etkr50fl, Women_etir50fl_2005, household_ethr50fl_rest_2005 for the year 2005 and ETKR60FL (child), ETIR60FL (women), ETHR60FL (household) for the year 2011. Data were imported from SPSS into SAS and for each year the data for the mother were merged with the child data set using 3 key identifier followed by a merge with the household data set using 2 key identifiers. As the data sets are large, the analysis could get cumbersome. To avoid this, the key variables of interest were identified followed by a concatenation of the data for the three surveys. Variables were transformed (e.g. log transformation if non normal data, conversion to binary form to facilitate analyses) as required. Any duplicate records generated were deleted. All data preparation and analysis was performed in SAS (SAS systems, 20XX). Information on weighting, conversions and merger of data sets and identification of matching identifiers was obtained from the DHS recode manuals (DHS Recode Manual: http://www.measuredhs.com/publications/publication-dhsg4-dhs-questionnaires-and-manuals.cfm, DHS Analysis Tips: http://www.measuredhs.com/data/Using-Datasets-for-Analysis.cfm, DHS Merging: http://www.measuredhs.com/data/Merging-Datasets.cfm)

Nutritional status Calculations

The key anthropometric indicators that are available in the DHS data are height for age Z-score, weight for age Z-score and weight for height Z-score. In the DHS 2011, these indicators are estimated using the WHO 2006 standards (reference) as well as the previous WHO/NCHS standards. However the data from DHS 2000 and 2005 have been calculated using only the WHO/NCHS standards. In order to be able to compare the different indices across the three years, data on weights and heights of the children were downloaded and anthropometric indices of height for age, weight for age and weight for height were re-calculated using the WHO 2006 standards. To maintain consistency, the study analyst also recalculated the indices for the DHS 2011. All anthropometric calculations were undertaken using pre-written SAS code that is available for download on the WHO website.[1]

Statistical analysis

Descriptive statistics were calculated for all key variables, by year, including means or frequencies as appropriate.Variables were weighted according to DHS survey weights. Pearson correlations coefficients were calculated to examine associations of key variables with stunting and identify variables to be included in the step-wise regression analyses. Descriptive statistics including mean HAZ and correlation coefficients for stunting with key variables were also

[1] Available at: http://www.who.int/childgrowth/software/en/

estimated for different subgroups, including, sex (gender), age, urban/rural and the different regions of Ethiopia. The regions that are included in the DHS data include: Addis Ababa, Affar, Amhara, Benishangul-Gumuz, Dire Dawa, Gambela, Harar, Oromiya, SNNPR, Somali region and Tigray. Using the conceptual hierarchical framework (Figure 1) and upon checking for normality, linear regression analyses and stepwise multivariate logistic regression analysis were conducted. The stepwise regressions allowed us to determine the effect of factors on a child under five being stunted (defined as HAZ < -2 SD), accounting for their position in the hierarchical framework.

The first step involvedtesting the association of being stunted against inherent factors such as age and sex (gender). Following this, variables that reflect distal factors were added to the model; followed by variables that reflect intermediate factors and finally the proximate factors. In all steps, those factors that hada p value of <0.10 were maintained in the model with the inherent factors being maintained through all the steps of the regression analysis. The final model thus contained only those factors that were significantlyassociated with the risk of being stunted. Furthermore, only those factors in the hierarchy were included that werenot mediated and/or represented by more proximate factors higher,thereby addressing the issue of collinearity. Post hoc tests on robustness of the models as well as tests of interactions between co-variates were conducted.Such analyses wereconducted on the data for years 2000, 2005 and 2011.

An issue that arises from examining individual and household level data within the same model is the effect of clustering especially if there is more than one individual observation (e.g. multiple children under five) in the same household. For the purpose of these analyses, when more than one child observation was found per household;the household was included as a cluster in the regressions to account for within household correlations.

All data were analyzed with the DHS weight variable included in the analyses. Following the above-mentioned analyses, specifically for the 2011 DHS data, analyses of dietary patterns and the risk of being stunted in children 6-24 months of age were conducted. In addition, analyses were conducted on examining the effect of presence of open defecation on the risk of being stunted. Pearson correlation coefficients and odds ratios were estimated followed by stepwise multivariate logistic regression to test the association of factors (dietary and non dietary) with the risk of being stunted in infants and young children 6-24 months of age.

Results

The following section focuses on the key findings of the analyses. The results focus on basic descriptive characteristics across the three survey years, examines the trends of stunting in Ethiopia across the different years (2000, 2005 and 2011), examines the variability in stunting by year, region and presents the findings of the regression analyses in determining factors associated with stunting across the three years. Data are also presented on relationships between diet and risk of stunting in the 2011 survey as well as sanitation variables and the risk of stunting in the 2011 survey.

Stunting and Height for Age Z-scores in 2011

As reported in the DHS 2011, overall stunting while high in Ethiopia had improved from 2005. Examining the data by age group (6-24 month and under five) and by region, we found that as of 2011, stunting is over 40% in Affar, Amhara, Benishangul-Gumu and Tigray with the highest rates in Tigray (52%). Rates in Oromiya, SNNPR, Dire Dawa, Gambela, Harar and Somali region range from 21-32% while Addis Ababa has the lowest rate of stunting at 13% (Figure 2).The prevalence of stunting is higher in the sample of all children under five years of age compared to the sub-sample of children 6-24 months, indicative of an incremental increase in prevalence as age increases (Figure 2). Data on changes over the time period 2000 to 2011 are presented later in Figures 7 and 8.

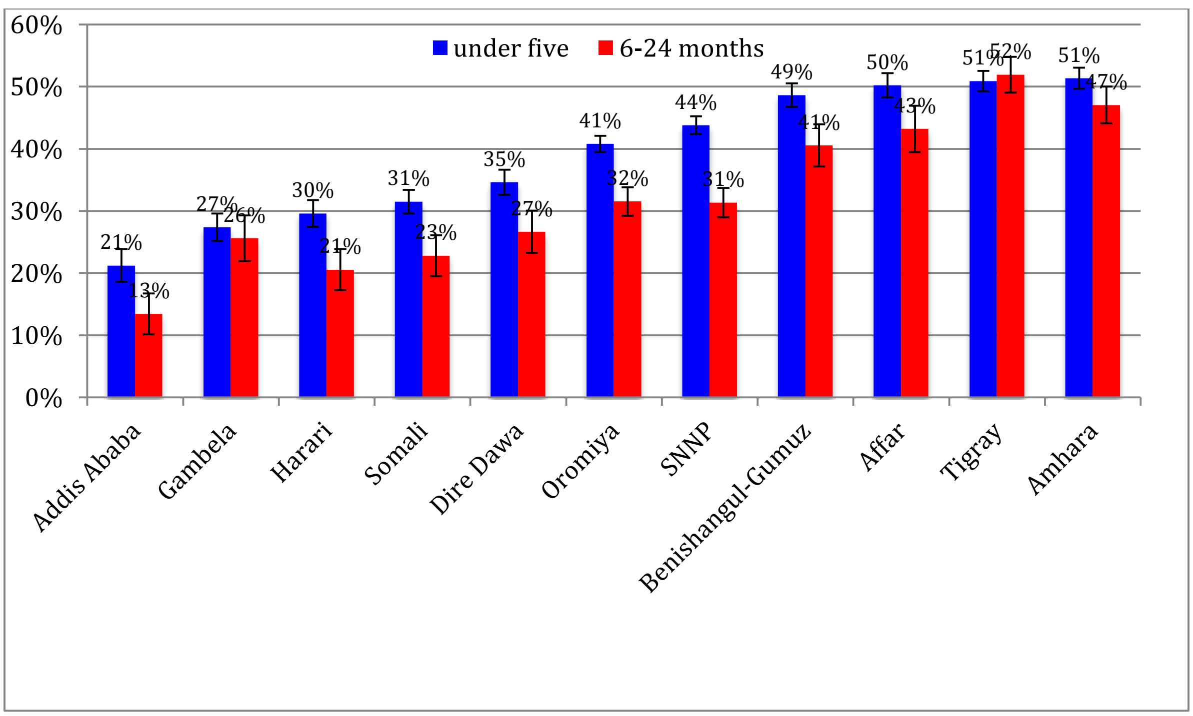


Figure 2: Stunting by region in DHS 2011 for children aged 6-24 months and under five years of age

Figure 3 presents the mean Height for Age z-scores from birth to five years of age in the DHS 2011. It can be seen from Figure 3 that the onset of the decline in mean HAZ beginsearly in life with mean Z-score for height for age being below 0.00 in the <6-month age category. The mean Z-scores decline and plateau at, or just below, -2 , in the 18-24 months and thereafter. .

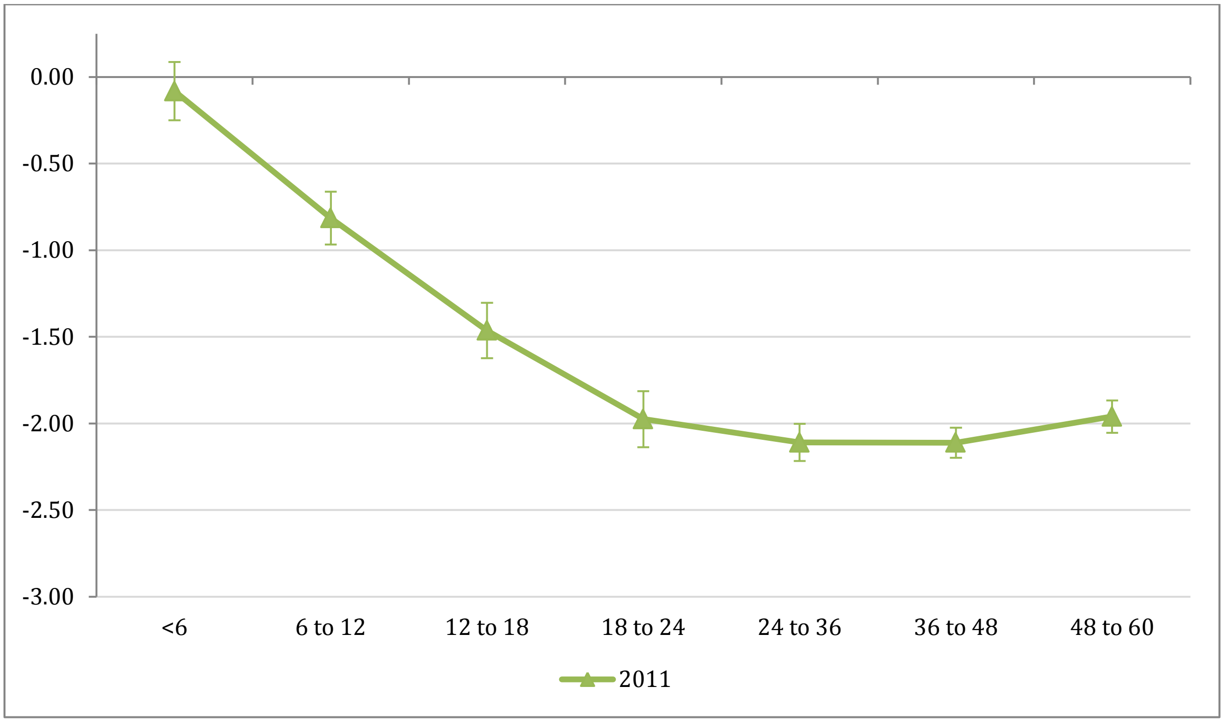


Figure 3: Height for Age Z-scores in DHS 2011

Figure 4 presents a comparison of the mean height for age Z-score in children under five years of age (total) relative to the mean height for age Z-score in children 6-24 months of age. This result and the data displayed in Figure 3 indicate that the lower HAZ score for children < 5 years when compared to the children aged 6-24 months is due to (1) the progressive decline in HAZ score during the first two years of life and (2) the persistence of this HAZ decrement during the following 3 years of life (24-36, 36-48, and 48-60 months of age).

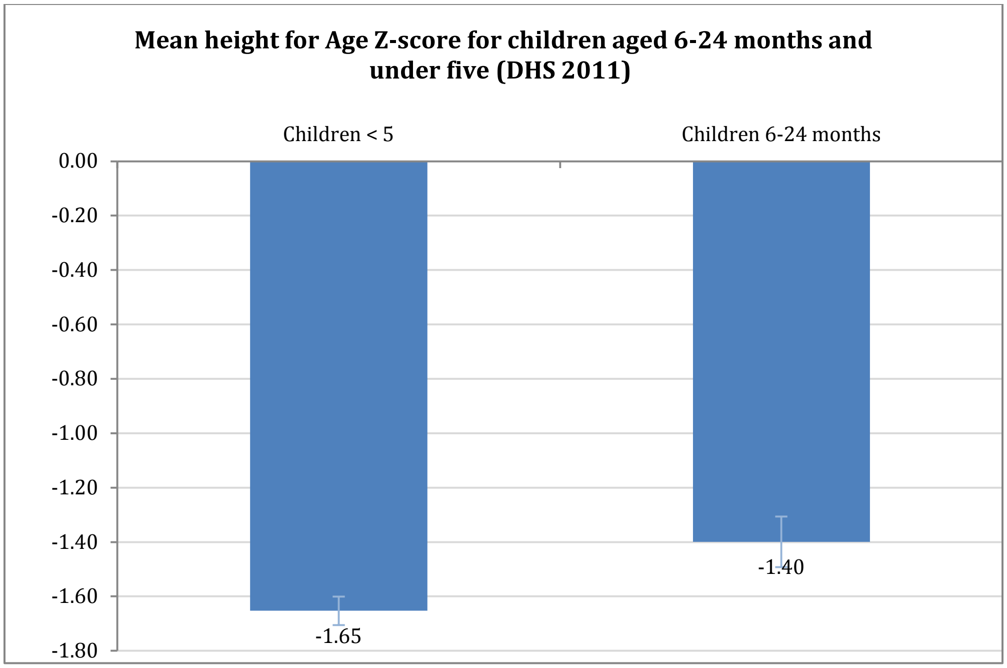


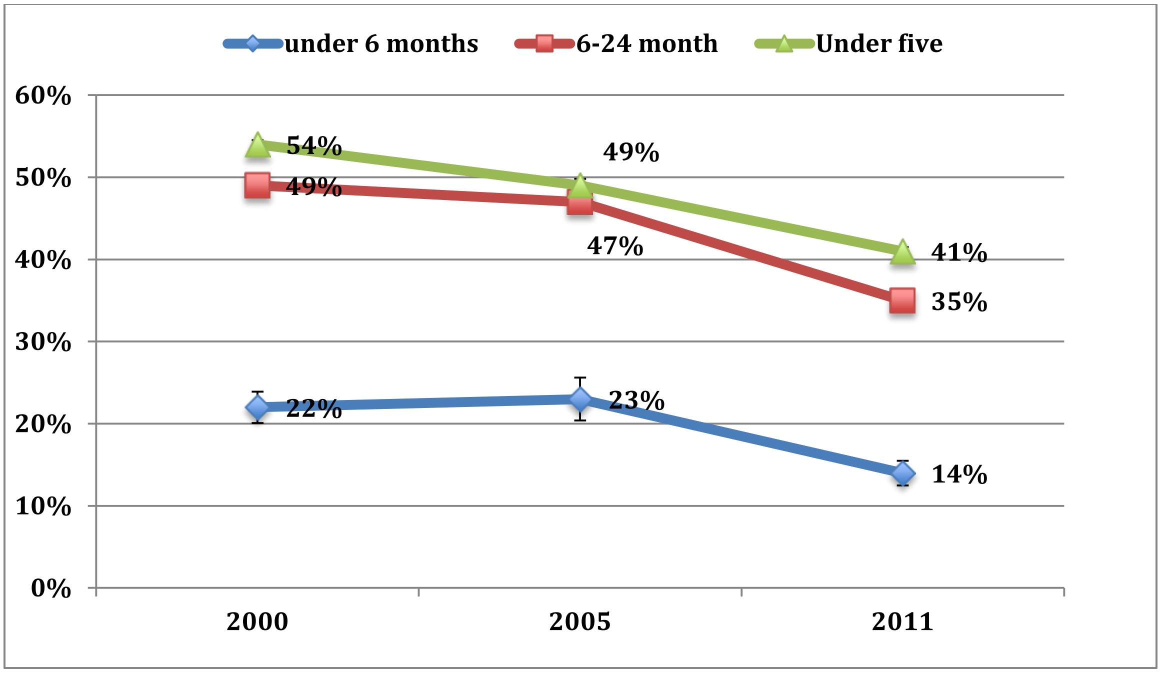
Figure 4: Height for Age Z-score for children aged 6-24 months and under five (DHS 2011)

Trends across survey years

Trends in Stunting and Height for Age

The prevalence of stunting was examined among Ethiopian infants under 6 months and compared to children aged 6-24 months and all children under five for the three survey years. The data are presented in Figure 5 by survey year. Significant decreases in stunting were found for all of the age ranges examined.

Amongst infants under 6 months of age, stunting rates have decreased significantly from 2000 through 2011 going from 22 and 23% to 14%. Stunting prevalence reduced from 49% in 2000 to 47% in 2005 and 35% in 2011 in children aged 6-24 months. Stunting prevalence in children under five) have also reduced significantly going from 54% in 2000 to 49% in 2005 and to 41% in 2011.



*(error bars are SE of Mean)

Figure 5: Prevalence of stunting in infants and children 6-24 months of age and under five by DHS year

Data on mean HAZ scores by year and age group are presented in Figure 6. As can be observed, similar to the DHS 2011, in both DHS 2000 and 2005, there is a drop in height for age Z-score (HAZ) as age increases especially between 6 to 24 months of age following which there is plateau in mean Z-score from 24 to 60 months. There has been a consistent and statistically significant improvement across all age groups in the mean Z-score with the lowest Z-scores by age group occurring in 2000 followed by 2005 and then 2011. As of 2011 the mean Z-scores for all children aged 18-24 months is ~ -2.00 SD..

Regional estimates and changes in HAZ scores are presented in Figure 7 and 8. The highest (best) HAZ scores are observed (across all years) in Addis Ababa with the lowest in Amhara and Tigray. While Z-scores have improved overall over time, they are still less than-2.0 in Amhara and Tigray. Furthermore, an improvement was observed in Affar from 2000 to 2005 however in 2011, the observed HAZ scores have dropped again. The region with the most improvement seems to be the Somali region where mean HAZ-scores for children under 5 of about -1.6 have reduced down to about -1.1 in the 2011 data. Of note, in Dire Dawa and Benishangul-Gumuzthe mean HAZ scoreshave not significantly improved between 2000 and 2011. In Gambela, mean HAZ scores have improved for children under 5 years but not for children aged 6-24 months during the 2000-2011 period.

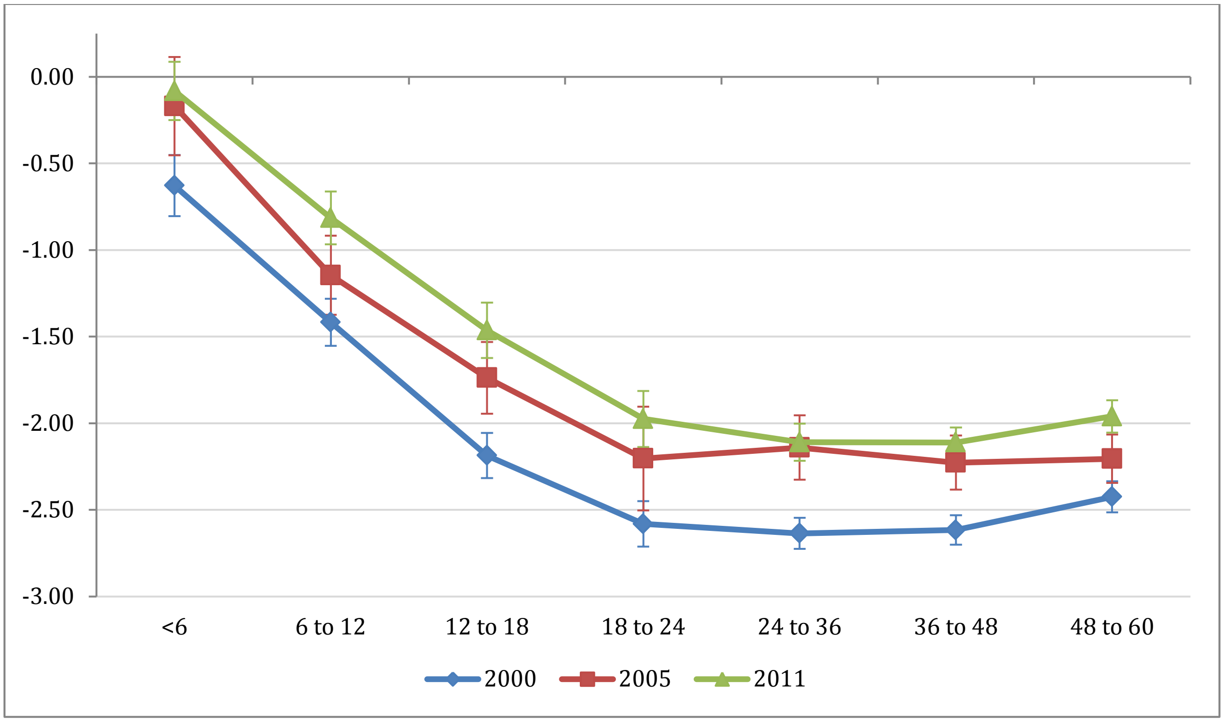


Figure 6: Mean HAZ by DHS year in children under five years of age

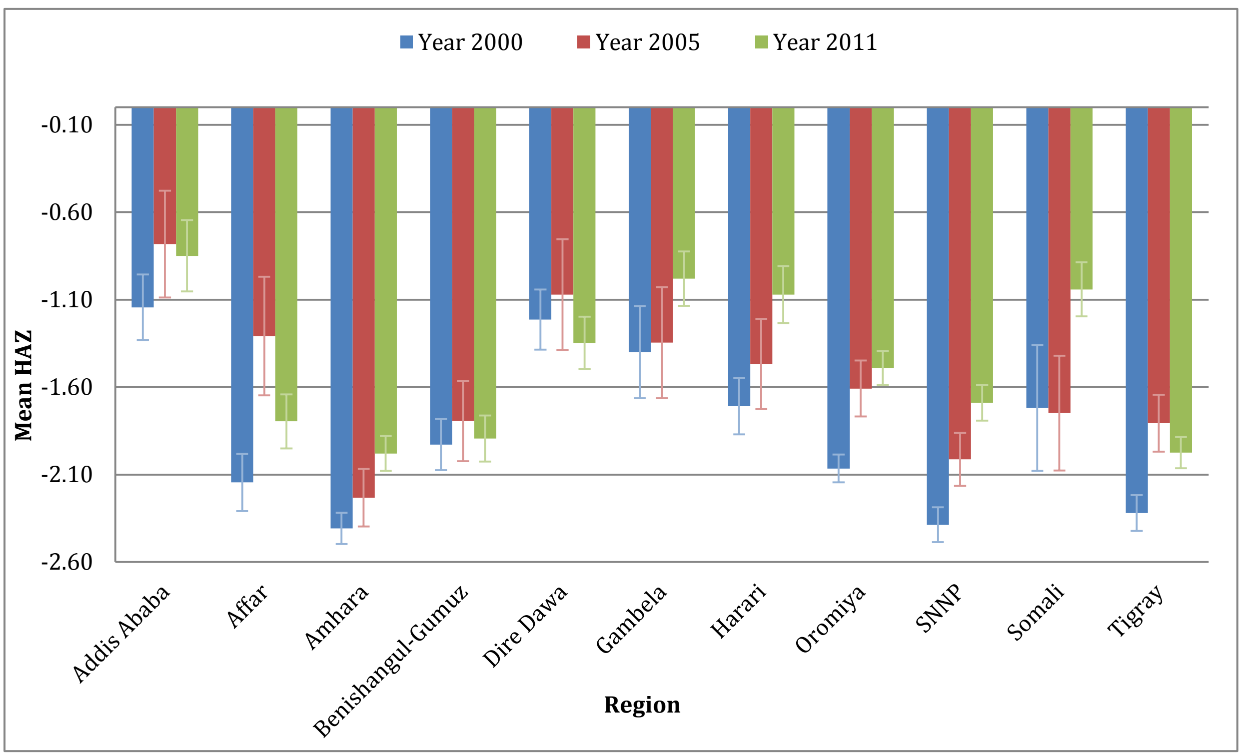


Figure 7: Mean HAZ by DHS year and region of Ethiopia in children under five years of age

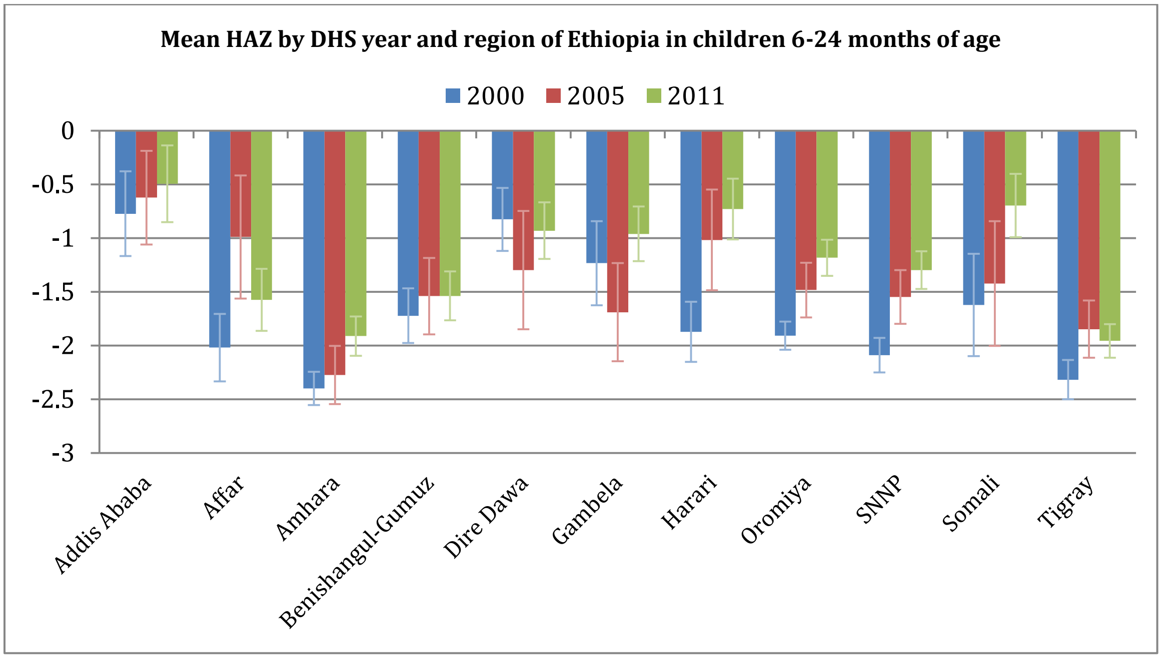


Figure 8: Mean HAZ by DHS year and region of Ethiopia in children 6-24 months of age

Demographic and Socio-economic trends

Demographic and socio-economic characteristics that were correlated with the risk of being stunted are presented by survey year in Table 3. The sample size ranged from 9845 (DHS 2005) to 10,873 (DHS 2000) and 11, 636 (DHS 2011). Mean age of the children included in the three surveys was 29.3 (±18.0) months in 2011, 28.8 (±18.4) months in 2005 and 29.2 (±18.2) months in 2000 with about 51% of children being male across the three survey years. Wealth index frequencies were available only for DHS 2005 and 2011. Frequencies are similar across the two survey years with about 44% classified in the poor and poorest category.

While other demographic characteristics are similar, there has been a change in the percentage of women with or without education across the three survey years. In 2000, 82% of mothers reported no education and only 13% had attended up to primary school, while in 2011, only 69% reported no education and 27% had attended up to primary school.

Table 3: Demographic and Socio-economic characteristics by survey year

Variables	Year of DHS Survey		
	2011 n=11636	**2005** n=9845	**2000** n=10873
Age of child (months)			
Mean (SE)	29.3 (18.0)	28.8 (18.4)	29.2 (18.2)
Gender, freq (%)			
Male	6160 (52.0)	5709 (51.2)	6288 (51.3)
Female	5688 (48.0)	5431 (48.8)	5972 (48.7)
Wealth index, freq(%)			N/A
Poorest	2699 (22.8)	2428 (21.8)	
Poorer	2654 (22.4)	2354 (21.1)	
Middle	2434 (20.5)	2482 (22.3)	
Richer	2272 (19.2)	2216 (19.9)	
Richest	1790 (15.1)	1659 (14.9)	
Mother's education, freq (%)			
None	8212 (69.3)	8816 (79.1)	10,063 (82.1)
Primary	3204 (27.1)	1855 (16.7)	1597 (13.0)
Secondary	264 (2.2)	426 (3.8)	573 (4.7)
Higher	169 (1.4)	43 (0.4)	28 (0.2)

Health and Nutrition Indicator trends

Table 4(next page) shows a comparison of key health and nutrition indicators across the three survey years including those indicators that were correlated with the risk of being stunted. There was been a very significant increase in latrine coverage from 2000 to 2011 with ~ 17% households reporting the presence of a latrine in 2000, ~ 31% in 2005, and ~ 58% in 2011. The use of an improved latrine was examined using both the Government of Ethiopia guidelines (pit latrine irrespective of presence of concrete slab) as well as the DHS definition, which requires a concrete or wooden slab. This important change might not have been revealed had only the DHS definition been studied.

In 2011, a lower percentage of households reported the use of an improved water source relative to 2005 and 2000, and in 2011 only 9% of households reported appropriate water treatment. Data for water treatment was not available for 2000 or 2005.

The mean time between births, or birth interval, increased very slightly (~ 1.3 months) over the three survey years. However birth size did not, with more infants in 2005 and 2011 being reported as being "very small" (20.6% in 2011, 20.5% in 2005 versus 5.8% in 2000). Note however that in both 2005 and 2011, the percentage of children being reported as "very small" was larger than those reported as "smaller than average," as well as the number of children being reported as being " very large" was greater than the "larger than average" category.

This counterintuitive information was re-confirmed from the datasets and the values we have are identical to those in the summary DHS reports.

The frequency of both DPT and measles immunization increased, while reports of polio vaccine remained the same. The mean height of mothers remained constant through the 3 survey years, while mean BMI went up slightly from 2000 to 2005 but did not change from 2005 to 2011. The mean number of antenatal visits reported went up very significantlyfrom 0.94 in 2000 to 1.62 visits in 2011.

Infant feeding practices and data were available only for the survey years of 2005 and 2011. Reports of feeding infants food or drink other than breastmilk in the first 3 days of life went up from 2005 to 2011, from 19% to 29% while rates of “still breastfeeding” have increased with about 44% women reporting as still breastfeeding compared to 19% for both 2005 and 2000 survey years.

Reports of a child having diarrhea, fever or cough in the past two weeks declined over the 2000-2011 period. Reports of diarrhea fell from 24.1% in 2000 to 13.6% in 2011; for cough, the respective numbers are 34.4% and 19.8%; and for fever, 29.0% and 17.3%.

Wealth and Stunting

Wealth index data were available only for the years 2005 and 2011. The mean HAZ score in children under the age of five by wealth index for the survey years 2005 and 2011 are presented in Figure 10. In both survey years mean HAZ remained low across all lower wealth indices and increased in the highest wealth index group. This increase was statistically significant in 2011. The HAZ score in both years for the poorest wealth category was ~ -1.8. We note that the HAZ score for the ‘poorer’ category was lower than the ‘poorest’ category in 2005 but this did not achieve statistical significance. HAZ-scores have increased between 2005 and 2011 in all categories except for the poorest category.

Table 4: Key Nutrition and Health Indicators across three survey years (weighted frequencies)

Variables	Year of DHS Survey		
	2011 n=11636	**2005** n=9845	**2000** n=10873
Presence of latrine (DHS definition), freq (%)			
Latrine	6860 (57.9)	3330 (30.9)	2105 (17.2)
No latrine	4988 (42.1)	7428 (69.0)	10,155 (82.8)
Improved latrine (Ethiopian definition), freq (%)			
Improved	6511 (56.5)	3239 (30.3)	1679 (14.2)
Not Improved	5011 (43.5)	7443 (69.7)	10155 (85.8)
Improved latrine (DHS definition), freq (%)			
Improved	794 (7.3)	624 (5.8)	1003 (8.6)
Shared or not improved	10135 (92.7)	10173 (94.2)	10623 (91.4)
Improved water source, freq (%)			
Improved	5026 (46.0)	9509 (88.1)	6253 (53.8)
Not improved	5896 (54.0)	1290 (11.9)	5375 (46.2)
Water Treatment, freq (%)		NA	NA
Appropriate treatment	998 (8.9)		
Inappropriate or not treated	10187 (91.1)		
Stool disposal, freq (%)			
Appropriate disposal	3997 (37.1)	5530 (68.3)	7742 (68.4)
Inappropriate disposal	6781 (62.9)	2570 (31.7)	3585 (31.7)
Birth order			
Mean (SE)	4.00 (0.05)	4.19 (0.04)	4.13 (0.04)
Birth interval (months)			
Mean (SE)	37.81 (0.34)	36.73 (0.28)	36.54 (0.30)
Birth size, freq (%)	*n=11608*	*n=9812*	*n=10858*
Very small	2434 (20.6)	2277 (20.5)	717 (5.8)
Smaller than average	1027 (8.7)	809 (7.3)	3369 (27.5)
Average	4534 (38.3)	4457 (40.1)	4376 (35.7)
Larger than average	1508 (12.7)	1055 (9.5)	3121 (25.5)
Very large	2293 (19.4)	2494 (22.5)	648 (5.3)
Mother’s height (cm)	*n=11393*	*n=4902*	*n=10806*
Mean (SD)	156.5 (6.1)	156.8 (6.8)	156.5 (6.9)
Mother’s BMI	*n=11384*	*n=4897*	*n=10794*
Mean (SE)	20.4 (2.6)	20.4 (2.6)	20.1 (2.4)
Gave food or drink other than breast milk in first 3 days of life, freq (%)	*n=7525*	*n=9444*	NA
Yes	2219 (28.9)	2056 (19.3)	
No	5454 (71.1)	8592 (80.7)	

Variables	Year of DHS Survey		
	2011 n=11636	**2005** n=9845	**2000** n=10873
Antenatal visits	*n=7722*	*n=6531*	*n=7178*
Mean (SE)	1.62 (0.04)	1.03 (0.03)	0.94 (0.03)
Immunizations, freq (%) that reported receiving/had on card	*n=10653*	*n=8464*	*n=9347*
DPT1	6150 (56.6)	4579 (46.1)	4454 (41.8)
Polio1	8361 (76.1)	6617 (65.8)	8038 (74.8)
Measles	5079(47.1)	2547 (26.9)	2723 (25.9)
Morbidity w/in last 2 weeks, freq (%)	*n=10913*	*n=10020*	*n=10523*
Diarrhea	1483 (13.6)	1814 (18.1)	2540 (24.1)
Fever	1885 (17.3)	1882 (18.9)	3052 (29.0)
Cough	2170 (19.8)	1845 (18.4)	3625 (34.4)
Breastfeeding Status, freq (%)	*n=11574*	*n=9768*	*n=10848*
Ever breastfed, not currently	6148 (52.1)	2141 (76.8)	4979 (79.8)
Never breastfed	432 (3.7)	93 (3.3)	53 (0.8)
Still breastfeeding	5217 (44.2)	535 (19.2)	1171 (18.8)

NA: data not available

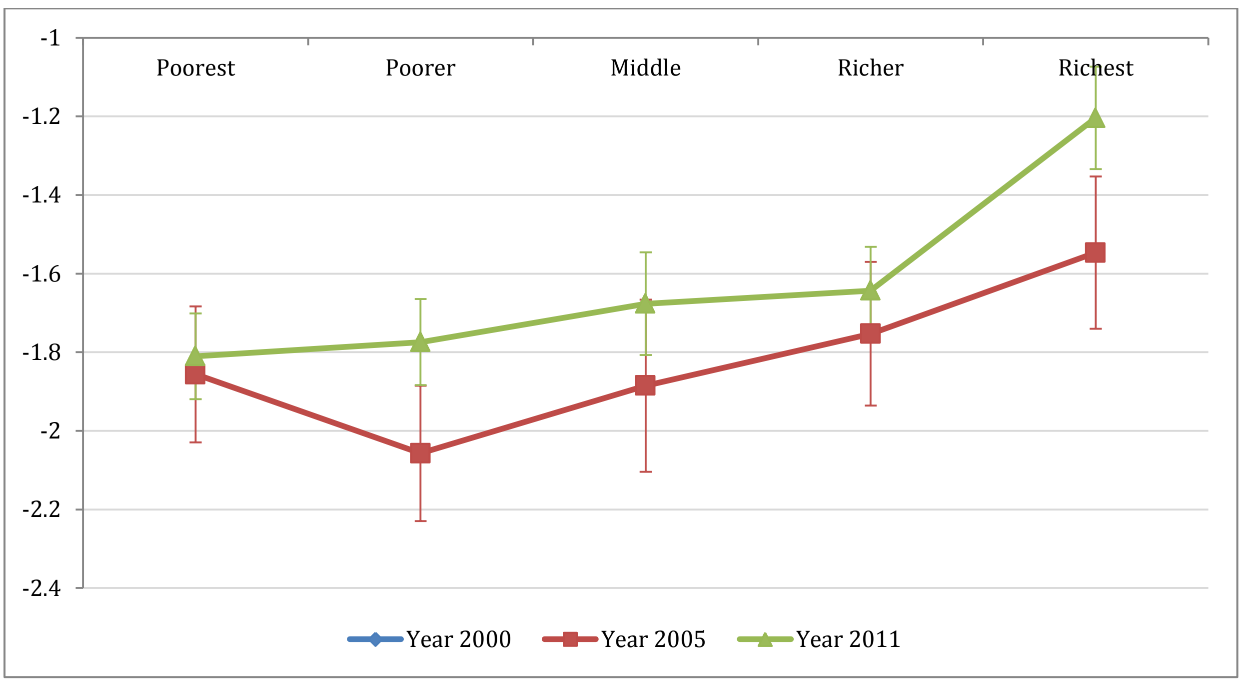


Figure 9: Mean HAZ score by wealth index and DHS year

Analyses of factors associated with stunting

Identification of key risk factors

The majority of variables identified in the hierarchical framework (Table 2 and Figure 1) andtested for incorporation into regression models were independently and significantly correlated with HAZ score and/or the risk of being stunted (Table 5) in children under the age of five. There was variability in the extent and strength of the correlation expressed as univariatePearson correlation coefficients. Associations with $p < 0.10$ were subsequently used in linear and logistic regression as detailed later in the report. As such these represent the first stage in identifying important factors.

In the text below, we report the univariateassociations as found in the data. At times the univariateassociations are strong, consistent, and have biological plausibility. As is often the case, a number of the factors when subsequently used in multivariate analyses were found to be of lesser or greater predictive value when compared to the univariateanalysis provided in this section. Indeed, some factors which appeared to be protective against stunting were in multivariate analysis or linear regressions were not protective, or vice-versa. Thus we caution the readers not to over-interpret these findings. Both consistent findings, and surprising results, will be highlighted as appropriate later on in the text.

In 2011, greater maternal height, greater maternal BMI, bigger birth size, andhigher maternal education were significantly protective against (negatively correlated with) the risk of being stunted as were betterwealth index, the number of antenatal visits, being "still breastfed", having a DPT vaccine reported on the health card,having a latrine, being a female child, consuming an animal source food in the past 24 hours, using appropriate methods for stool disposal, having access to an improved water source, and using appropriate water treatment. In contrast, increasing age, a measles vaccine reported on the card, higherbirth order, having a pre-lacteal feed and the number of meals in the past 24 hours and dietary diversity were positively and significantly correlated with the risk of being stunted.

In 2005, maternal height, maternal BMI, education, longer birth interval, and larger birth size were negatively and significantly correlated with (protective against) the risk of being stunted as were the number of antenatal visits, higher wealth index, still being breastfed, having cough in the past two weeks and having a DPT vaccine. Lack of a latrine and diarrheain the past two weeks, and higher birth order, were significantly positively correlated with the risk of being stunted, as was age.

In 2000, maternal height, education, birth interval, birth size were also negatively and significantly correlated with (protective against) the risk of being stunted as were being still breast fed, being a female child and having a DPT vaccine. Factors that were positively correlated to the risk of being stunted included having a measles or polio vaccine, birth order, number of meals in the past 24 hours, lack of latrine, diarrhea in the past two weeks as well as age. Across all three years, consistently, maternal height, education, birth interval and birth size were negatively correlated with the risk of being stunted while age and lack of a latrine was positively correlated with risk of being stunted. Most of these also had high correlation coefficients. Wealth index data were available only for years 2005 and 2011 but in both years, the wealth index was significantly negatively correlated with the risk of being stunted.

Table 5: Pearson correlation coefficients between stunting/Height for age Z-score and key variables in 2011, 2005, and 2000 survey data

Variable	**2011**		**2005**		**2000**	
Pearson Correlation Coefficient	Stunting	HAZ	Stunting	HAZ	Stunting	HAZ
p-value						
Age (mos)	**0.22**	**-0.31**	**0.17**	**-0.25**	**0.22**	**-0.28**
	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Female sex (gender)	**-0.04**	**0.03**	**-0.04**	**0.04**	**-0.02**	**0.03**
	<0.01	<0.01	0.01	0.02	0.04	0.01
Wealth Index	**-0.12**	**0.11**	**-0.11**	**0.09**	.	.
	<0.0001	<0.0001	<0.0001	<0.0001	.	.
Maternal education	**-0.13**	**0.14**	**-0.13**	**0.12**	**-0.15**	**0.17**
	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
# Antenatal visits	**-0.12**	**0.11**	**-0.13**	**0.09**	**-0.13**	**0.15**
	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Number of meals in past 24 hours	**0.17**	**-0.21**	.	.	**0.17**	**-0.22**
	<0.0001	<0.0001	.	.	<0.0001	<0.0001
Diet diversity (# food groups consumed)	**0.03**	**-0.05**	.	.	.	.
	0.05	<0.01	.	.	.	.
DPT vaccine reported or on card	**-0.02**	-0.01	-0.03	0.01	<0.01	0.02
	0.02	0.28	0.06	0.7	0.78	0.12
Polio vaccine reported or on card	0.01	**-0.05**	-0.01	-0.01	**0.04**	**-0.03**
	0.56	<0.0001	0.46	0.51	<0.01	<0.01
Measles vaccine reported or on card	**0.06**	**-0.12**	0.01	**-0.06**	**0.03**	**-0.04**
	<0.0001	<0.0001	0.67	<0.01	<0.01	<0.01
Birth order	**0.04**	**-0.03**	**0.04**	-0.03	**0.05**	**-0.06**
	<0.01	<0.01	0.01	0.1	<0.0001	<0.0001
Birth interval (months)	**-0.09**	**0.09**	**-0.09**	**0.13**	**-0.09**	**0.11**
	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Birth size (subjective)	**-0.06**	**0.06**	**-0.07**	**0.05**	**-0.06**	**0.07**
	<0.0001	<0.0001	<0.0001	<0.01	<0.0001	<0.0001
Maternal Height	**-0.18**	**0.19**	**-0.14**	**0.15**	**-0.15**	**0.17**
	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001	<0.0001
Improved latrine (DHS Definition)	**-0.06**	**0.06**	**-0.07**	**0.05**	**-0.06**	**0.09**

Variable	2011		2005		2000	
	<0.0001	<0.0001	<0.0001	<0.01	<0.0001	<0.0001
Improved latrine (Ethiopian definition)	**-0.06**	**0.04**	**-0.08**	**0.08**	**-0.09**	**0.10**
	0.002	0.02	0.003	0.01	<0.0001	<0.0001
Improved Water Source	**-0.07**	**0.05**	-0.01	0.02	**-0.07**	**0.07**
	<0.0001	<0.0001	0.47	0.33	<0.0001	<0.0001
Maternal BMI	**-0.09**	**0.1**	**-0.05**	**0.06**	**-0.07**	**0.09**
	<0.0001	<0.0001	<0.01	<0.01	<0.0001	<0.0001
Diarrhea in last 2 weeks	0.02	**-0.02**	**0.04**	**-0.04**	**0.04**	**-0.05**
	0.1	0.03	0.01	0.02	<0.01	<0.0001
Fever in last 2 weeks	0.01	**-0.03**	0.01	-0.01	**0.02**	**-0.04**
	0.33	0.01	0.6	0.56	0.03	<0.01
Cough in last 2 weeks	<0.01	<0.01	-0.02	0.02	**0.03**	**-0.04**
	0.94	0.76	0.26	0.34	<0.01	<0.0001
Gave food other than breast milk w/in first 3 days	0.01	0.01	**-0.04**	**0.05**	.	.
	0.65	0.52	0.01	<0.01	.	.
Still Breastfeeding	**-0.12**	**0.18**	**-0.05**	**0.09**	**-0.1**	**0.13**
	<0.0001	<0.0001	<0.01	<0.0001	<0.0001	<0.0001
Appropriate Water Treatment	**-0.04**	**0.05**	.	.	.	.
	<0.0001	<0.0001	.	.	.	.
Appropriate stool disposal	**-0.05**	**0.04**	0.01	-0.01	**-0.03**	**0.05**
	<0.0001	<0.0001	0.64	0.66	<0.01	<0.0001

. : data not available; bold font indicates p<0.05

Factors associated with mean height for ageZ-scores in 2011

Linear regression analyses were next conducted to examine the relationship between height for age Z-score in children under five years of age and associated risk factorsin DHS 2011. The final model is presented in Table 6. As age increases, HAZ score decreases (as per Figure 3). Having introduced food other than breast milk within the first 3 days of birth and continued breastfeeding are associated with a lower HAZ score. In contrast, not having polio or measles vaccine, higher wealth index, a longer birth interval, higher maternal education, bigger birth size, higher maternal height and more antennal visits are associated with a higher HAZ score. While improved water source, improved latrine, water treatment and stool disposal were significantly correlated with stunting in univariate analysis (as seen in Table 5), they were not significant predictors of height for age Z-scores in the multivariate linear regression model, indicative of other factors that seem to exert stronger effects on the risk of being stunted.

Table 6: Linear regression model of factors associated with HAZ (DHS 2011)

Variables**	2011 **n=5280**		
	*Coefficient**	*95% CI*	
Intercept	**-7.89**	-9.59	-6.20
Age (months)	**-0.05**	-0.06	-0.05
Female sex	**0.14**	0.01	0.26
Maternal education	**0.13**	0.02	0.25
Wealth Index	**0.09**	0.04	0.15
Birth order	**0.03**	0.00	0.05
Birth interval (months)	**0.00**	0.00	0.01
Birth size	**0.13**	0.08	0.18
Maternal Height (cm)	**0.05**	0.04	0.06
Polio vaccine reported/on card	**-0.12**	-0.23	-0.01
Measles vaccine reported/on card	**-0.20**	-0.30	-0.10
# Antenatal visits	**0.06**	0.03	0.09
Maternal BMI			
Gave food other than breast milk w/in first 3 days	**-0.14**	-0.28	0.00
Still Breastfeeding	**-0.71**	-0.89	-0.53
Adjusted R-square	0.22		

* Bold font indicates significant at p<0.05; blank indicates that factor was not included in final model; NA=variable not available

**Variables that were not significant in any model: Improved latrine (DHS and Ethiopia definitions), improved water source, birth order, cough in last 24 hours, appropriate water treatment, appropriate stool disposal

Factors associated with the risk of being stunted in 2011

The predictors of stunting in all children under the age of five for 2011 are presented in Table 7.Factors associated with the risk of being stunted included age, male sex, low wealth index, birth interval, smaller birth size, lower maternal height, lower maternal BMI,fewer antenatal visits, and the child having had diarrhea or fever in the past 2 weeks. If the childwas still being breastfed or had been introduced to foods/drinks other than breast milk within first three days of birth the risk of stunting was elevated. Specifically, the strongest effects/associations includedwealth with infants and young children born to mothers in the poorest households being 2.2 times more likely to be stunted than those who were born to mothers in the richest households. Note that each of the wealth index categories significantly differed from the reference (richest) category in a consistent trend. Furthermore, girls were 25% less likely to be stunted then boys. Infants and children reported to have a very small birth size were twice (2.02) as likely to be stunted as those that were very large at birth. For every unit increase in the maternal indicators height (cm.) and BMI (mass in kg/[height in m]^2), children were about 6% and 3%, respectively, less likely to be stunted. Note that maternal education was not significant in this model although the trend of increasing education was consistent with a beneficial effect. A similar consistent trend was seen for reported birth size.

Table 7: Stepwise multivariate regression of hierarchical factors on risk of stunting (2011)

Factors associated with stunting***	Adjusted odds ratios *
	2011 n=5275
Age (months)	**1.06** (1.05-1.07)
Sex of child	
Female	**0.75**(0.63-0.90)
Male	Ref
Maternal Education	
None	1.76 (0.51-6.03)
Primary	1.76 (0.51-6.00)
Secondary	0.99 (0.25-3.98)
Higher	Ref
Wealth Index	
Poorest	**2.20** (1.50-3.23)
Poorer	**2.06** (1.40-3.03)
Middle	**1.91** (1.30-2.81)
Richer	**1.86** (1.27-2.73)
Richest	Ref
Birth interval (months)	**0.99** (0.99-1.00)
Birth size	
Very small	**2.02** (1.53-2.65)
Smaller than average	1.26 (0.87-1.82)
Average	1.24 (0.97-1.60)
Larger than average	1.15 (0.82-1.61)
Very large	Ref
Maternal height (cm)	**0.94** (0.93-0.96)
Measles vaccine reported/on card	**1.23** (1.08-1.41)
Maternal BMI	**0.97** (0.94-1.00)
Diarrhea in last 2 wks	**1.44** (1.14-1.82)
Fever in last 2 wks	**0.76** (0.61-0.96)
Number of antenatal visits	**0.95** (0.91-0.99)
Gave food other than breast milk w/in first 3 days	**1.21** (1.00-1.48)
Still breastfeeding	**2.10** (1.60-2.74)
Max-rescaled R-square	0.23

* Bold font indicates significant at p<0.05; blank indicates that factor was not included in final model; NA=variable not available
***Variables that were not significant in any model: Improved latrine (DHS and Ethiopia definitions), improved water source, birth order, DPT vaccine, appropriate water treatment, appropriate stool disposal

Factors associated with the risk of being stunted by age group in 2011

A series of logistic regression models by age group for DHS 2011 are shown in Table 8. In infants < 6 months of age, the final model included maternal height and the introduction of any food or drink in the first 3 days of life. Only maternal height was a significant predictor of stunting in this age range with every unit increase in centimeterslinked to an 8% risk reduction for stunting. In infants aged 6-12 months, the factors included in the final model age (1.5 x increased risk of being stunted per month of additional age), being a girl (39% less risk), wealth index (not significant, NS), birth size with very small infants 2.7 times more likely to be stunted, maternal height (7% lower risk per maternal cm), still breastfeeding (NS) and diet diversity with higher number of food groups consumed being associated with a 27% lower risk of being stunted. Factors forthe 12-24 months age group included age, being a boy, wealth index (NS), maternal education (NS), birth size, maternal height and still being breastfed. Similar to the 6-12 month age group, age, male sec, very small birth size and lower maternal height were significant predictors for stunting. For children > 24 months of age, in addition to the factors seen in the 12-24 month age group, predictive factors included birth interval, maternal BMI, having had a diarrheal episode and a fever two weeks prior to the survey.

Table 8: Stepwise multivariate regression of hierarchical factors on risk of stunting, comparison of final model factors between age groups (DHS 2011)

Factors associated with stunting**	Odds ratios by age group*			
	< 6 months n=1020	6-12 months n=966	12-24 months n=1773	>24 months n=4708
Age (months)		**1.49** (1.29-1.71)	**1.09** (1.05-1.14)	1.00 (0.99-1.01)
Female sex	0.77 (0.44-1.33)	**0.61** (0.38-0.97)	**0.65** (0.48-0.87)	0.94 (0.79-1.12)
Maternal Education				
None			4.41 (0.78-24.87)	3.42 (0.90-12.98)
Primary			4.01 (0.72-22.48)	3.66 (0.96-13.88)
Secondary			1.41 (0.21-9.56)	1.88 (0.37-9.59)
Higher			Ref	Ref
Wealth Index				
Poorest		2.12 (0.88-5.08)	1.71 (0.98-2.99)	**1.70** (1.22-2.38)
Poorer		2.02 (0.82-4.96)	1.36 (0.77-2.40)	**1.69** (1.20-2.38)
Middle		1.70 (0.67-4.32)	1.57 (0.89-2.78)	**1.57** (1.12-2.20)
Richer		1.93 (0.74-5.01)	1.04 (0.58-1.87)	**1.56** (1.11-2.17)
Richest		Ref	Ref	Ref
Birth interval (mos)				**0.99** (0.99-1.00)
Birth size				
Very small		**2.78** (1.23-6.31)	**1.90** (1.19-3.04)	**1.33** (1.00-1.76)
Smaller than average		1.17 (0.38-3.57)	1.16 (0.63-2.13)	1.00 (0.70-1.42)
Average		1.15 (0.53-2.50)	1.25 (0.81-1.93)	1.03 (0.82-1.30)
Larger than average		0.84 (0.29-2.46)	1.35 (0.78-2.35)	0.96 (0.70-1.30)
Very large		Ref	Ref	Ref
Maternal height (cm)	**0.92** (0.88-0.97)	**0.93** (0.89-0.97)	**0.92**(0.90-0.95)	**0.95** (0.93-0.96)
Maternal BMI				**0.95** (0.92-0.98)
Diarrhea in last 2 wks				**1.54** (1.12-2.10)
Fever in last 2 wks				**0.71** (0.55-0.93)
Diet diversity		**0.73** (0.56-0.95)		NA
Gave food other than breast milk w/in first 3 days	1.71 (0.96-3.05)			NA
Still breastfeeding		3.26 (0.92-11.61)	**2.48** (1.51-4.08)	**1.90** (1.49-2.43)
Max-rescaled R-square	0.06	0.22	0.17	0.09

* Bold font indicates significant at p<0.05; blank indicates that factor was not included in final model; NA=variable not available

**Variables that were not significant in any model: Improved latrine (DHS and Ethiopia definitions), improved water source, birth order, any vaccine, cough in last 24 hours, antenatal visits, appropriate water treatment, appropriate stool disposal

We note the consistency of the effect of maternal height and very small birth size across all the age ranges examined, and the consistency of the effect of gender through 24 months of age. The central estimates of the effects of wealth are in consistent across the age range of 6-60 months although statistically significant only for children > 24 months, which had the largest sample size for analysis.

Comparison of factors associated with stunting and with mean height for age Z-scores across survey years

The models and adjusted odds ratios comparing 2011, 2005 and 2000 withthe most significant associations between risk factors and stunting in children < 5 years of age are presented in Table 9. In 2005, similar to 2011, factors associated with stunting included age, sex, birth interval, birth size, and maternal height and having diarrhea in the past two weeks. In addition, diarrhea orcough in the past 2 weeksor still being breast-fed were factors that were all associated with stunting in the final model. The strongest associations were with very small birth size babies (1.5 times more likely to be stunted vs. reference very large babies), andchildren who had had diarrhea in the past two weeks who were 1.4 times more likely to be stunted. Infants born to taller mothers were 10% less likely to be stunted for every unit cm increase in height. Cough in the past two weeks (23% less likely to be stunted) as well as still being breastfed (2.89 times more likely to be stunted) were significant factors.

In 2000, significant factors included age, sex, education, having no latrine, birth interval, birth size, having had a polio vaccine, maternal height, diarrhea in the past 2 weeks, number of antenatal visits, and still being breast fed. Strongest associations were found with maternal education, birth interval, birth size with smaller than average babies being 1.8 times more likely to be stunted than reference group babies, maternal height (5% less likelihood of being stunted if born to a taller mother) and diarrhea in the past two weeks (infant 1.3 times more likely to be stunted if suffering from diarrhea). Common predictors of stunting among all three survey years included age, sex, birth interval, birth size and maternal height, while the factors associated with stunting that were unique to 2011 included maternal BMI,if food was given in the first three days of life,and wealth. (In 2000, there were only 22 women in the reference category of higher education, which may account for the unusually high relative risk values of 45-91 for lesser education).

Multivariate linear regression estimates of the association of the hierarchical factors with mean height for age Z-score across survey years are presented in Table 10. Factors that were associated with mean HAZ score were similar across the three years. Specifically in 2005, diarrhea in past two weeks was associated with a lower mean HAZ score while in the 2000 analysis, maternal BMI was positively associated with HAZ score and presence of an improved latrine (pit latrine with or without slab and all other forms of improved latrines) was significantly and positively associated with HAZ score. The latter was not significant in any of the other survey years.

Table 9: Stepwise multivariate stepwise logistic regression of hierarchical factors on risk of being stunted: comparison of final model factors between 2011, 2005, 2000 DHS survey years

Factors associated with stunting***	Adjusted odds ratios by survey year*		
	2011 n=5275	2005 n=3225	2000 n=5043
Age (months)	**1.06** (1.05-1.07)	**1.05**(1.04-1.06)	**1.06**(1.05-1.07)
Sex of child			
Female	**0.75**(0.63-0.90)	**0.75** (0.62-0.91)	**0.73**(0.62-0.86)
Male	Ref	Ref	Ref
Maternal Education			
None	1.76 (0.51-6.03)	1.38 (0.33-5.70)	**91.44** (10.18-821.39)
Primary	1.76 (0.51-6.00)	1.10 (0.26-4.63)	**83.23** (9.27-747.16)
Secondary	0.99 (0.25-3.98)	1.27 (0.29-5.67)	**44.71** (4.84-412.97)
Higher	Ref	Ref	Ref
Wealth Index			NA
Poorest	**2.20** (1.50-3.23)		
Poorer	**2.06** (1.40-3.03)		
Middle	**1.91** (1.30-2.81)		
Richer	**1.86** (1.27-2.73)		
Richest	Ref		
No household latrine			**1.26** (1.00-1.60)
Birth interval (months)	**0.99** (0.99-1.00)	**0.99** (0.98-0.99)	**0.99**(0.99-1.00)
Birth size			
Very small	**2.02** (1.53-2.65)	**1.55** (1.14-2.10)	**1.58** (1.01-2.49)
Smaller than average	1.26 (0.87-1.82)	1.21 (0.84-1.75)	**1.80** (1.23-2.63)
Average	1.24 (0.97-1.60)	**1.36** (1.06-1.75)	1.15 (0.79-1.67)
Larger than average	1.15 (0.82-1.61)	0.90 (0.64-1.28)	1.02 (0.70-1.50)
Very large	Ref	Ref	Ref
Maternal height (cm)	**0.94** (0.93-0.96)	**0.95**(0.94-0.97)	**0.95** (0.93-0.96)
Polio vaccine reported/on card		1.13 (0.99-1.29)	**1.32** (1.17-1.48)
Measles vaccine reported/on card	**1.23** (1.08-1.41)		
Maternal BMI	**0.97** (0.94-1.00)		
Diarrhea in last 2 weeks	**1.44** (1.14-1.82)	**1.38** (1.08 -1.76)	**1.31** (1.10-1.56)
Cough in last 2 weeks		**0.77**(0.60-0.99)	
Fever in last 2 weeks	**0.76** (0.61-0.96)		
Number of antenatal visits	**0.95** (0.91-0.99)		**0.94** (0.89-0.98)
Gave food other than breast milk w/in first 3 days	**1.21** (1.00-1.48)		NA
Still breastfeeding	**2.10** (1.60-2.74)	**2.88**(2.15-3.87)	**1.76** (1.38-2.25)
Max-rescaled R-square**	0.23	0.16	0.23

* Bold font indicates significant at p<0.05; blank indicates that factor was not included in final model; NA=variable not available

** Max-rescaled R-square for logistic regression measures the change in the likelihood function between an intercept only model and a model with the independent variables. (Not the proportion of variance explained in the dependent variables as is the case in multiple linear regression).

***Variables that were not significant in any model: Improved latrine (DHS and Ethiopia definitions), improved water source, birth order, DPT vaccine, appropriate water treatment, appropriate stool disposal

Table 10: Comparison of stepwise multivariate linear regression of hierarchical factors and height for age Z-score in children under five years of age for 2011, 2005, 2000DHS survey years

Variables**	2011 **n=5280**			2005 **n=3225**			2000 **n=4936**		
	*Coefficient**	*95% CI*		*Coefficient*	*95% CI*		*Coefficient*	*95% CI*	
Intercept	**-7.89**	-9.59	-6.20	**-7.08**	-9.28	-4.88	**-8.42**	-10.11	-6.73
Age (months)	**-0.05**	-0.06	-0.05	**-0.05**	-0.06	-0.04	**-0.05**	-0.06	-0.05
Female sex	**0.14**	0.01	0.26	**0.18**	0.02	0.34	**0.24**	0.13	0.36
Maternal education	**0.13**	0.02	0.25	0.12	-0.03	0.26	**0.12**	0.00	0.25
Wealth Index	**0.09**	0.04	0.15				NA		
Birth order	**0.03**	0.00	0.05						
Birth interval (months)	**0.00**	0.00	0.01	**0.01**	0.01	0.02	**0.01**	0.00	0.01
Birth size	**0.13**	0.08	0.18	**0.07**	0.01	0.14	**0.13**	0.08	0.19
Maternal Height (cm)	**0.05**	0.04	0.06	**0.04**	0.03	0.06	**0.04**	0.03	0.05
Improved Latrine (Ethiopia definition)							**0.24**	0.06	0.43
Polio vaccine reported/on card	**-0.12**	-0.23	-0.01	**-0.17**	-0.29	-0.05	**-0.21**	-0.29	-0.12
Measles vaccine reported/on card	**-0.20**	-0.30	-0.10						
Diarrhea in last 2 weeks				**-0.38**	-0.59	-0.17	**-0.29**	-0.42	-0.16
Cough in last 2 weeks				0.13	-0.07	0.33			
# Antenatal visits	**0.06**	0.03	0.09				**0.06**	0.03	0.09
Maternal BMI							**0.03**	0.00	0.06
Gave food other than breast milk w/in first 3 days	**-0.14**	-0.28	0.00				NA		
Still Breastfeeding	**-0.71**	-0.89	-0.53	**-0.87**	-1.13	-0.60	**-0.55**	-0.72	-0.39
R-square	0.22			0.14			0.21		

* Bold font indicates significant at p<0.05; blank indicates that factor was not included in final model; NA=variable not available
**Variables that were not significant in any model: Improved latrine (DHS definition), improved water source, birth order, DPT vaccine, fever in last 24 hours, appropriate water treatment, appropriate stool disposal

Analyses of factors by region

As noted in Figure 1, there is significant variability in stunting across the different regions of Ethiopia. In this section we explore the correlations between specific predictors/factors identified in the multivariate regression analyses across the survey years by region in Ethiopia specifically in children aged 6-24 months of age in the 2011 data (Table 11). Individual models by region are beyond the scope of this report and are likely to be adversely affected by the smaller number of clusters and sample size per cluster is low.

Table 11: **Correlation of key variables with stunting in children 6-24 months, 2011, by region**

Pearson correlation p-value	Addis	Affar	Amhara	Benishangul-Gumuz	Dire Dawa	Gambela	Harari	Oromiya	SNNP	Somali	Tigray
n	*111*	*237*	*333*	*258*	*181*	*208*	*168*	*458*	*432*	*215*	*329*
Age (mos)	**0.21**	**0.36**	**0.25**	**0.47**	**0.26**	**0.26**	**0.21**	**0.26**	**0.20**	**0.26**	**0.30**
	0.03	<0.0001	<0.0001	<0.0001	0.00	0.00	0.01	<0.0001	<0.0001	0.00	<0.0001
Female sex	0.00	-0.08	-0.04	**-0.13**	-0.04	-0.07	-0.15	**-0.13**	**-0.10**	**-0.13**	**-0.12**
	1.00	0.20	0.50	0.03	0.56	0.30	0.06	0.01	0.04	0.05	0.03
WealthIndex	.	-0.07	-0.09	-0.05	**-0.23**	0.09	-0.15	-0.08	**-0.10**	-0.13	**-0.20**
	.	0.28	0.09	0.45	0.00	0.19	0.06	0.09	0.05	0.06	0.00
Maternal education	**-0.19**	-0.09	-0.06	0.00	**-0.23**	0.05	0.03	-0.03	**-0.11**	**-0.24**	**-0.20**
	0.05	0.15	0.28	0.96	0.00	0.52	0.74	0.49	0.03	0.00	0.00
Birth Order	**0.23**	**0.14**	-0.01	0.06	0.13	-0.07	0.12	-0.04	0.03	0.07	-0.03
	0.02	0.03	0.89	0.32	0.08	0.34	0.12	0.41	0.58	0.28	0.64
Birth interval (months)	-0.19	-0.06	**-0.12**	-0.09	-0.13	0.12	-0.10	-0.05	0.04	-0.06	**-0.15**
	0.17	0.43	0.04	0.19	0.12	0.12	0.25	0.33	0.42	0.38	0.01
Birthsize	-0.11	**0.13**	-0.09	0.03	-0.14	-0.13	-0.13	**-0.10**	-0.07	-0.12	**-0.20**
	0.25	0.05	0.09	0.66	0.06	0.07	0.08	0.04	0.13	0.08	0.00
Maternal Height	-0.08	**-0.13**	**-0.22**	-0.12	-0.12	**-0.22**	-0.08	**-0.17**	**-0.19**	**-0.19**	**-0.30**
	0.38	0.05	<0.0001	0.06	0.12	0.00	0.32	0.00	<0.0001	0.00	<0.0001
LatrineImproved (DHS definition)	**-0.20**	-0.03	-0.02	-0.07	-0.13	0.00	-0.12	-0.05	-0.09	0.11	**-0.23**
	0.04	0.70	0.74	0.24	0.09	0.95	0.14	0.28	0.07	0.11	<0.0001
Latrine Improved (Ethiopia)	-0.09	-0.05	-0.01	**-0.12**	**-0.25**	**0.17**	-0.11	-0.03	-0.07	-0.05	**-0.15**
	0.37	0.45	0.88	0.05	0.00	0.02	0.16	0.52	0.17	0.43	0.01
WaterImproved	.	-0.05	-0.06	0.09	-0.08	0.07	-0.12	-0.06	0.02	-0.05	**-0.21**
	.	0.46	0.27	0.15	0.30	0.29	0.13	0.22	0.63	0.43	0.00
DPT vaccine reported or on card	0.04	0.00	**-0.14**	-0.11	0.04	0.04	-0.09	**-0.13**	-0.04	0.00	-0.11

Pearson correlation p-value	Addis	Affar	Amhara	Benishangul-Gumuz	Dire Dawa	Gambela	Harari	Oromiya	SNNP	Somali	Tigray
	0.66	0.98	0.01	0.09	0.56	0.54	0.27	0.00	0.37	0.94	0.06
Polio vaccine reported or on card	-0.03	-0.08	**-0.12**	-0.10	0.06	-0.02	0.00	**-0.10**	-0.05	0.00	-0.08
	0.79	0.23	0.03	0.13	0.45	0.73	0.96	0.03	0.32	0.97	0.12
Measles vaccine reported or on card	0.09	**-0.16**	**0.14**	0.07	**0.25**	0.05	0.05	0.01	-0.04	0.11	0.09
	0.33	0.01	0.01	0.29	0.00	0.50	0.51	0.81	0.43	0.10	0.09
Number of antenatal visits	-0.09	-0.09	-0.07	-0.07	**-0.24**	**-0.15**	**-0.16**	-0.09	-0.06	-0.10	**-0.21**
	0.33	0.18	0.20	0.29	0.00	0.03	0.04	0.06	0.26	0.17	0.00
Number of Meals in last 24 hours	0.05	0.04	0.04	**0.17**	**0.17**	0.12	0.10	**0.19**	0.01	-0.06	0.11
	0.65	0.54	0.55	0.01	0.03	0.10	0.21	0.00	0.79	0.40	0.06
DietDiversity (# of food groups in last 24 hours)	0.03	0.04	0.02	0.11	0.03	0.05	-0.01	0.07	-0.06	**-0.14**	0.02
	0.75	0.58	0.71	0.08	0.65	0.45	0.92	0.13	0.22	0.04	0.71
MaternalBMI	-0.07	0.01	0.03	-0.02	**-0.18**	-0.06	**-0.18**	-0.06	-0.07	-0.10	-0.08
	0.44	0.92	0.61	0.76	0.02	0.39	0.02	0.22	0.13	0.16	0.13
Diarrhea in last 2 weeks	-0.09	0.09	-0.05	0.01	-0.01	0.13	0.07	0.09	0.04	-0.06	0.01
	0.37	0.19	0.41	0.83	0.86	0.06	0.37	0.07	0.45	0.39	0.81
Fever in last 2 weeks	0.01	0.02	-0.05	0.06	0.06	0.13	-0.01	0.01	-0.01	0.09	0.05
	0.91	0.75	0.34	0.36	0.39	0.06	0.85	0.82	0.85	0.19	0.36
Cough in last 2 weeks	-0.05	-0.01	-0.08	0.01	**0.15**	0.01	-0.09	0.02	0.00	-0.03	0.03
	0.64	0.87	0.14	0.82	0.04	0.84	0.23	0.60	0.95	0.62	0.59
Introduction of food/drink in the first three days after birth	-0.15	-0.05	0.00	-0.05	0.00	-0.12	0.00	0.05	0.02	-0.12	0.04
	0.14	0.46	0.94	0.46	0.98	0.09	0.95	0.30	0.70	0.10	0.46
StillBreastfeeding	-0.03	-0.11	0.01	-0.11	-0.12	-0.05	**-0.25**	**0.12**	0.05	0.01	-0.06
	0.75	0.08	0.93	0.09	0.12	0.46	0.00	0.01	0.28	0.89	0.26

Pearson correlation p-value	Addis	Affar	Amhara	Benishangul-Gumuz	Dire Dawa	Gambela	Harari	Oromiya	SNNP	Somali	Tigray
Appropriate StoolDisposal	-0.07	-0.09	-0.05	-0.05	**-0.23**	0.12	0.02	0.09	-0.02	**-0.14**	**-0.11**
	0.48	0.15	0.33	0.45	0.00	0.09	0.75	0.06	0.73	0.05	0.05
Meat	-0.05	**-0.13**	0.01	**0.14**	0.03	0.02	-0.07	-0.01	0.03	-0.12	0.05
	0.63	0.05	0.80	0.03	0.70	0.80	0.39	0.90	0.59	0.08	0.34
Eggs	-0.05	**-0.15**	-0.02	0.00	0.02	-0.02	0.00	0.03	**-0.12**	-0.09	-0.01
	0.60	0.03	0.70	0.96	0.82	0.82	1.00	0.50	0.02	0.21	0.84
Fish	0.17	-0.04	0.01	**0.13**	-0.08	-0.07	0.14	-0.02	-0.03	-0.04	-0.06
	0.07	0.54	0.92	0.04	0.33	0.32	0.08	0.74	0.51	0.54	0.27
Grains, Roots & Tubers	0.12	0.03	0.10	**0.14**	**0.25**	**0.21**	0.07	0.09	0.07	**-0.14**	0.08
	0.22	0.64	0.07	0.03	0.00	0.00	0.37	0.07	0.18	0.04	0.15
Legumes	0.15	0.08	-0.02	-0.01	-0.13	-0.05	-0.03	**0.13**	-0.05	0.06	-0.07
	0.12	0.24	0.71	0.93	0.10	0.47	0.67	0.01	0.28	0.42	0.23
Dairy	-0.18	0.01	-0.07	-0.10	-0.07	-0.02	-0.02	0.02	**-0.12**	-0.10	0.03
	0.06	0.90	0.25	0.12	0.35	0.77	0.79	0.66	0.01	0.15	0.65
Yelloworange veg	-0.05	-0.05	-0.03	-0.06	0.08	0.00	0.08	0.02	0.00	-0.01	-0.04
	0.61	0.46	0.62	0.35	0.32	0.95	0.34	0.72	0.94	0.87	0.48
Greenleafy veg	-0.05	**0.19**	-0.02	0.09	0.03	-0.04	0.08	-0.01	0.01	0.11	0.08
	0.61	0.00	0.73	0.14	0.71	0.62	0.33	0.77	0.86	0.13	0.18
Vitamin Afruits	0.05	0.06	-0.02	**0.13**	0.02	0.05	-0.09	-0.04	-0.02	-0.02	-0.02
	0.61	0.34	0.68	0.05	0.77	0.49	0.26	0.44	0.71	0.79	0.67

Association of Diet with the risk of being stunted

In this section we examine the relationship of dietary patterns and sanitation with stunting prevalence by region in Ethiopia to understand any possible differences in the relationship of dietary patterns and the risk of being stunted in children 6-24 months of age.

A frequency analyses shows that a large majority of Ethiopian infants and young children consumed grains, roots and/or tubers (71%), but other food groups were far less commonly consumed, dairy being the next most consumed (30%). Meat, and other fruits/vegetables, were consumed the least (5% and 4%, respectively) (Figure 10). Consumption of dairy and other fruits/vegetables was negatively associated with (protective against) being stunted, while consumption of grains, roots and/or tubers was positively associated with stunting. Children who consumed dairy in the past 24 hours were less likely to be stunted (OR=0.72); those who consumed grains, roots and/or tubers and legumes were more likely to be stunted (OR=1.52 and 1.35, respectively) (Table 12).

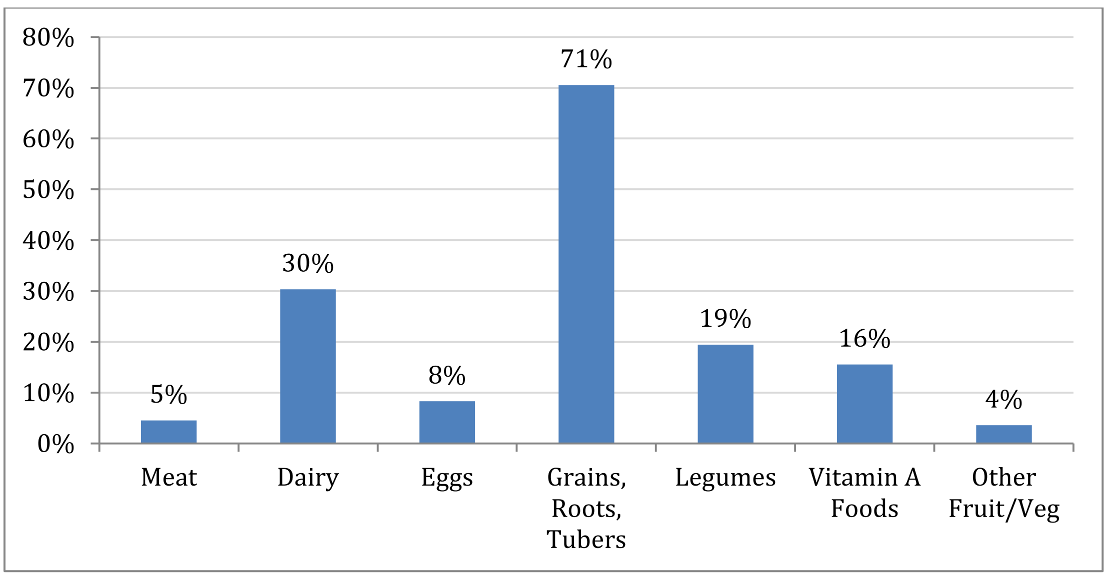


Figure 10: Percent of children 6-24 months who consumed each food group in last 24 hours, 2011

Table 12: Correlations and odds ratios of food groups consumed in the last 24 hours and stunting in children 6-24 months, 2011

	Pearson Correlation with stunting rate	Odds ratio
Meat	0.019	1.2
Dairy	**-0.071**	**0.72**
Eggs	-0.014	0.9
Grains, Roots, Tubers	**0.089**	**1.52**
Legumes	**0.058**	**1.35**
Vitamin A Foods	-0.033	0.82
Other Fruit/Veg	**-0.059**	**0.47**

Bold = p<0.05

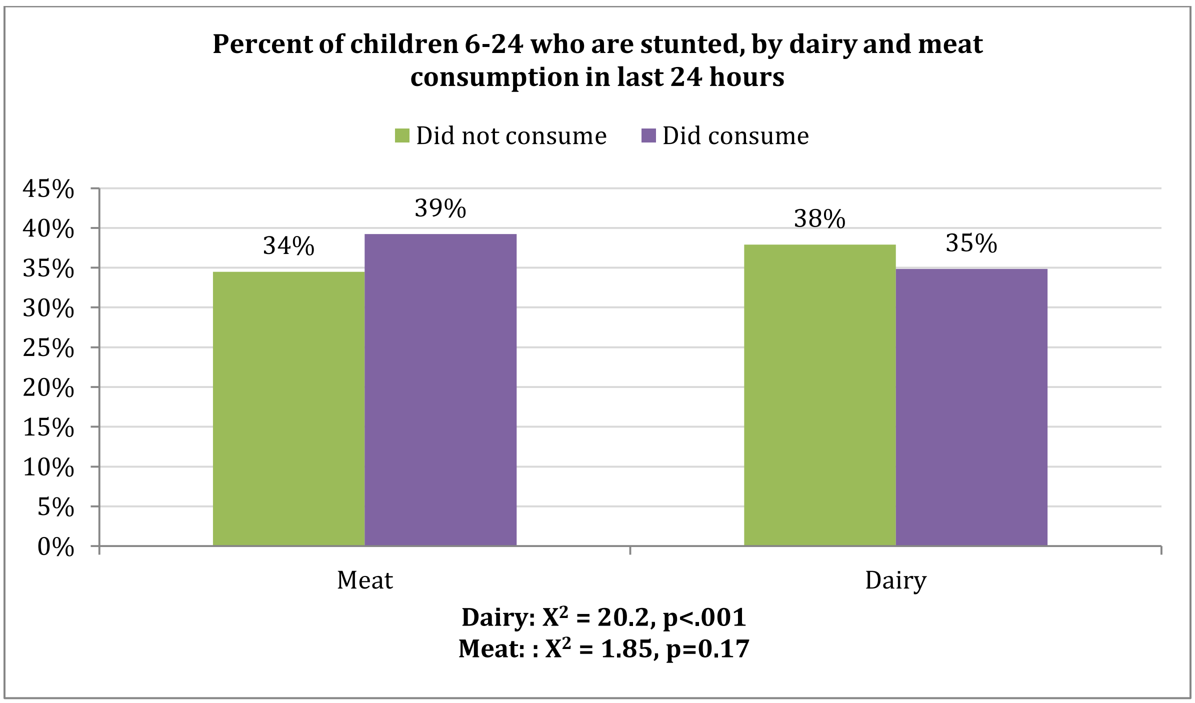


Figure 11: Percentage of children (6-24 months) that are stunted by dairy and meat consumption

Examining dairy and meat consumption in stunted versus non-stunted children showed that children who consumed dairy were less likely to be stunted (χ^2= 20.2, p<0.01). Meat consumption was directionally but not significantly associated with stunting. A stratified dietary analysis shows highly variable differences by region in intake of animal source foods including dairy, meat and eggs among children 6-24 months of age (Figure 8 displays regional differences of stunting). The Somali region had the highest intake of dairy among children (75% reported dairy consumption in the last 24 hours), while the lowest dairy intake was found in Amhara, with only 13% reporting dairy consumption in the last 24 hours. The highest intake of both meat (20%) and eggs (18%) was found in Gambela, while the lowest intake of meat in the last 24 hours was found in SNNP (2%) and the lowest intake of eggs found in

Somali (2%). Significant associations of consumption of meat, dairy or eggs was found only in four regions, with dairy intake in the past 24 hours negatively associated with stunting in Addis Ababa; meat and egg intake was negatively associated with stunting in Affar; meat intake was positively associated with stunting in Benishangul-Gumuz; and dairy and eggs were negatively associated with stunting in SNNP (Table 13).

Simple odds ratios for dietary intake variables and other risk factors with stunting are shown in Table 14. In Benishangul-Gumuz, consumption of meat and grains, roots and tubers were both associated with an increased likelihood of stunting among children 6-24 months. Consumption of grains, roots and tubers in the last 24 hours was significantly associated with an increased likelihood of stunting in Benishangul-Gumuz, Dire Dawa and Gambela, while trending toward significance in Amhara and Oromiya, and trending toward a decreased likelihood of stunting in Somali. Having no latrine was significantly associated with an increased likelihood of stunting in Dire-Dawa and Tigray, while significantly associated with a decreased likelihood in Gambela.

A review of animal source food consumption by region shows the variability in consumption across the different regions. Dairy was the most commonly consumed animal source food ranging from 75% in Somali region to 29% in Oromiya. Rates of dairy consumption were low in Amhara, Benishangul-Gumuz and Tigray (Figure 12). Meat and egg consumption was very low throughout the country. Examining the relationship of stunting to consumption of dairy, one can see that about 26% of variation in stunting by region can be explained by the consumption of dairy products (Figure 13).

Table 13: Association* between stunting and consumption of meat, dairy or eggs, by region, in children 6-24 months, 2011

	Addis Ababa	Affar	Amhara	Benishangul -Gumuz	Dire Dawa	Gambela	Harari	Oromiya	SNNP	Somali	Tigray
N	108	225	312	239	170	196	156	438	390	203	315
Meat	-0.05	**-0.13**	0.01	**0.12**	0.03	0.02	-0.07	-0.01	0.05	-0.12	0.05
Dairy	**-0.18**	0.01	-0.07	-0.09	-0.08	-0.02	-0.04	0.02	**-0.12**	-0.1	0.03
Eggs	-0.05	**-0.15**	-0.02	-0.02	0.02	-0.02	0	0.03	**-0.12**	-0.09	-0.01

*Pearson correlation coefficient, Bold = p<0.05

Table 14: Odds ratios by region between stunting and risk factors, in children 6-24 months, 2011

	Addis Ababa	Affar	Amhara	Benishangul -Gumuz	Dire Dawa	Gambela	Harari	Oromiya	SNNP	Somali	Tigray
N	108	225	312	239	170	196	156	438	390	203	315
Meat				**2.5**							
Dairy	*0.3*								**0.6**		
Eggs									**0.1**		
Grains, roots and tubers			*1.6*	**1.8**	**3.9**	**2.8**		*1.6*		*0.5*	
No latrine					**3**	**0.5**					**1.8**
Still breast feeding					*0.5*		**0.2**				
Legumes								**1.9**			

Bold = p<0.05, italics=p<0.10

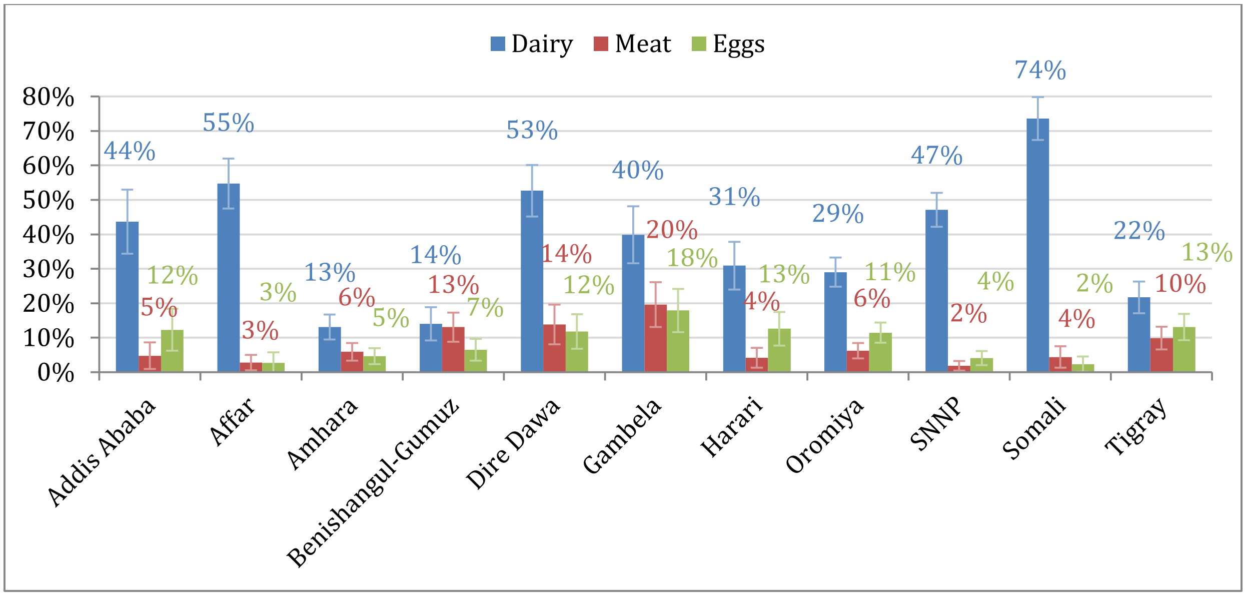


Figure 12: Percent of children 6-24 months who consumed dairy, meat or eggs in last 24 hours, by region, 2011

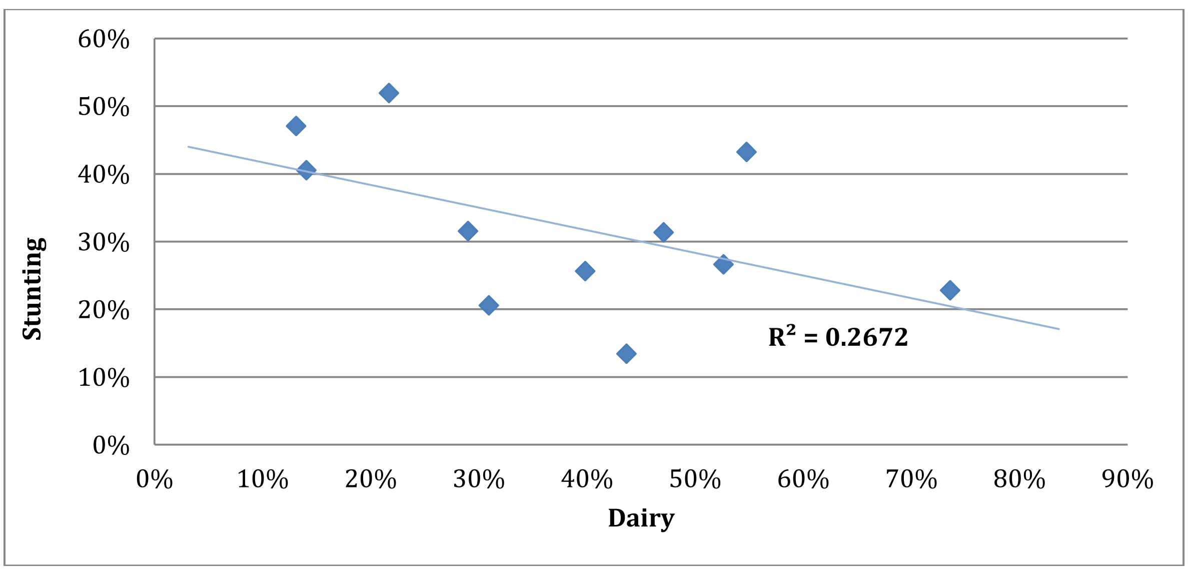


Figure 13: Relationship between dairy in the last 24 hours and stunting in children 6-24 months of age by region

Open Defecation and Risk of being stunted

An analysis of the relationship between open defecation (absence of latrine) and stunting at the regional level was conducted. Figure 14 presents the overall frequencies key water and sanitation (WASH) variables while Table 15 presents the analysis of the relationship between mean height for age Z-scores in children under five years of age, open defecation and key nutrition variables. Lack of a latrine was significantly associated with the risk of being stunted however the significance was lost when variables such as wealth index and maternal height were included into the model. The effect of maternal height and wealth was retained when the survey year was controlled for. That being said, the model incorporating open defecation, wealth index and maternal height explained 71% of the variation in stunting observed in the three survey years. A model examining the relationship of improved latrine (both DHS and Ethiopian definitions) was also estimated and having an improved latrine facility was positively and significantly associated with height for age Z-score, a significance that was retained when maternal height was added to the model but lost when wealth was incorporated (Table 15).

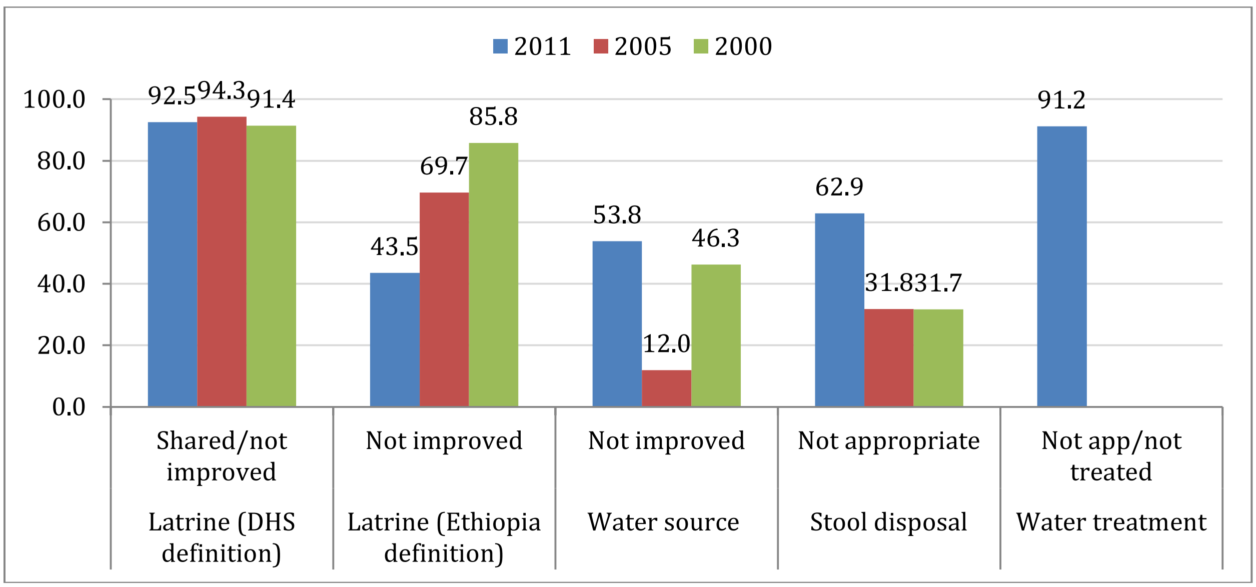


Figure 14: Water and sanitation facilities by survey year

Table 15: Relationship between Mean Height for Age, open defecation and key nutrition, and socio-economic indicators

Variable	Model						
Open defecation (no latrine)	-1.001 **	0.277 NS	-0.190 NS	0.166 NS			
Improved latrine (DHS Definition)					3.504 **	3.278 ***	0.467 NS
Wealth index		0.286 *	0.244 *	0.316 **			0.258 *
Maternal height			0.124 ***	0.124 ***		0.097 **	0.124 ***
DHS year				*0.036*			0.030 NS
N regions	33	22	22	22	33	33	22
R square	0.29	0.27	0.66	0.71	0.27	0.49	0.71

** p<0.05
**** p<0.01

Discussion and Conclusion

Factors that are known to increase the risk of stunting include poor infant and young child feeding practices, high levels of diarrheal morbidity, low birth weight or size, maternal education, care giving practices, and overall socio-economic status of the household (7, 12-14). This study aimed to examine the risk factors associated with stunting using DHS data from 2011 and compare the trends and changes in risk factors associated with stunting in Ethiopian children across different survey years (DHS 2000, 2005 and 2011). The objectives of the study were to examine the trends and variability in stunting across different years, regions and socio-economic strata, to identify the risk factors associated with stunting using the DHS 2011 data and examines the change in risk factors associated with stunting across the different DHS years. The analyses used a conceptual framework proposed by Wamani et al that categorizes factors affecting height for age in infants and young children as inherent, distal, intermediate and proximate in nature (10). According to this framework inherent factors include age and gender of the child while household socio-economic status, education of parents, household assets and wealth and ownership are distal factors. Intermediate factors include presence of latrines, maternal age, and deworming status and immunization status. Proximate factors include use of pre-lacteal feeds, breast-feeding status, use of high quality complementary foods (animal source foods, fortified cereal legume blends, micronutrient powders) and morbidity (fever, cough, acute respiratory infections, diarrhea).

Using this framework to identify the key variables to include in step wise logistic and multivariate regressions, we found that prevalence of stunting increases while mean height for age Z-score decreases as age increases. Stunting onset in Ethiopian children is early in life with a drop in height for age being observed by 6-12 months of age, which continues to 18-24 months of life, and continues at the same prevalence until the age of 5 years is reached.

Comparing across the three survey years, a similar trend is observed. This trend exists irrespective of the survey year.

In Ethiopia, a number of factors have been identified which contribute to poor linear growth, e.g. stunting. Analyses have been conducted with older DHS data as well as primary cross sectional data in the different regions of Ethiopia. Prior analysis of the 2000 Ethiopia Demographic and Health Survey found that biological factors (age of child and maternal stature) as important determinants (15) as well as socio-economic factors such as household wealth and mothers' education. The author of that report also found significant externalities associated with access to water and sanitation at the community level. Other data analyses have shown similar results with household resources, parental education, maternal nutritional knowledge and food prices being key determinants of linear growth. The authors however found that the link to community sanitation, health and communication infrastructure was less robust. Authors indicated that this was possibly because of confounding factors, such as the quality of health care or lack of variation in the variables (14). In general, our analyses confirm and provide additional confidence in these findings.

An increasing body of evidence points in the direction of access to clean water, maternal stature and birth size of the infant as potential determinants of stunting as well. There are also concerns of the intergenerational effects of poor linear growth. We provide additional evidence to support these determinants as being important in Ethiopia. In our analysis, the factors associated with stunting included age, gender, wealth, maternal height and BMI, birth interval, birth size, maternal education, and having reported diarrhea in the past 2 weeks(The latter may be a marker not only of an adverse health event but also a marker of household or community sanitation). Girls were 20% less likely to be stunted then boys. Small birth size was associated with a 50% higher risk of being stunted. Infants and young children in the poorest wealth index group were 1.8 times more likely to be stunted than children in the richest wealth index group. Maternal height was a particularly strong and consistent predictor of stunting with a reduction in stunting risk of 6% with every unit increase in height (cm). This is an important and interesting finding given that an analysis of data from 54 low to middle income countries (109 Demographic and Health surveys conducted from 1991 to 2008) found that a 1 cm increase in maternal height is associated with a decreased risk of child mortality of 1.2%, a 3.2% decreased risk of being stunted, and a 3.2% decrease risk of being underweight. Our analysis focused on stunting suggests that the benefits of increased maternal height in Ethiopia (6% less stunting per maternal cm of increased height) are even greater than this global study suggests.

There is variability in risk factors associated with stunting when examined by age group. This likely reflects biological, social and environmental influences, whichincreasingly come into play over time and as the developing child transitions to complementary foods and greater independence. In infants under 6 months of age assessed in 2011, the final model included the variables maternal height and the introduction of foods in the first three days with giving any food/drink to the infant in the first three days. Only maternal height was a significant predictor of the risk of being stunted in infants under 6 months of age with every unit increase in maternal height being associated with a 8% reduction of risk of being stunted. For the age range 6-12 months (Table 8) maternal height remained a key determinant and an additional set of factors became evident: age, gender of the child, birth size, household wealth, and intriguingly dietary diversity and continued breastfeeding were part of the final model. Continued breastfeeding beyond the age of 6 months – found to be a predictor for stunting in not only the group aged 6-12, but also older children – may represent an issue around inappropriate feeding practices. Factors in the final model for the age group 12-24 months included age, being a boy, wealth index ($p < 0.10$ and > 0.05), maternal education ($p < 0.10$ and > 0.05), birth size, maternal height and still being breastfed. Similar to the 6-12 month age group, age, being a girl, very small birth size and maternal height were significantly associated with the risk of being stunted. Finally in children greater than 24 months of age, in addition to the factors seen in the 12-24 month age group, stunting was also associated with birth interval, maternal BMI, having had a diarrheal episode and with not having had a fever two weeks prior to the survey. The latter might be dismissed as a spurious finding, however malnourished children are well known to be*less likely* to have fever or cough as a sign of infection than are well-nourished children.

Comparing trends across the period 2000 to 2011 shows several common risk factors associated with stunting (Tables 9 and 10). Common predictors of stunting inall three survey years included age, sex, birth interval, birth size and maternal height, while the factors associated with stunting that were unique to 2011 included maternal BMI, if food was given in the first three days of life, and low wealth index. The estimated magnitude of the effect varied somewhat by year but was often extremely robust. For example, in multivariate analysis for stunting in children under 5, the relative risk of stunting for very small birth size was 1.58 in 2000, 1.55 in 2005, and 2.02 in 2011. Efforts to reduce low birth weight should thus have a major impact on stunting. The reduction in risk of stunting provided by an unit increase (1 cm) in maternal height was also consistent and robust, being 5% less in 2000, 5% less in 2005, and 6% less in 2011 (Table 8). This provides evidence that successful efforts to decrease stunting in children will later lead to greater maternal height and less intergenerational conveyance of risk due to undernutrition.

The finding that children > 6 months who are still being breastfed had a consistently increased risk of stunting (RR 1.76 in 2000, 2.88 in 2005, 2.10 in 2010) certainly warrants investigation. Others have suggested that mothers may choose to continue breastfeeding the most ill children beyond the age of 6 months, and thus persistent breastfeeding may be a marker of illness and undernutrition rather than a cause(16). If this is true in Ethiopia then it may provide a tool for identifying children at significantly higher risk of stunting. It is important to note that associations found in the analysis of DHS data can provide evidence not only of causality, but also of reverse causality.

In the 2000 data the strongest associations were found with low maternal education, shorter birth interval, small birth size (as discussed above), maternal height (5% less likelihood of being stunted if born to a taller mother) and diarrhea in the past two weeks (a childis 1.3 times more likely to be stunted if it had been reported to have diarrhea in the preceding two weeks). The latter finding was also a consistent one across all three years and confirms the importance of interrupting the chain of transmission for diseases with WASH interventions. As noted earlier diarrheal disease can be related not only to personal and household hygiene but also to community level factors. We found evidence of an interaction with household wealth and maternal stature as outlined in the section on open defecation and stunting, discussed below.

Linear regression analyses were used to examine the relationship of mean height for age Z-scores with key risk factors across the three survey years. Factors that were associated with mean HAZ score were similar across the three years and helped confirm the results from multivariate analyses, as outlined above. Specifically in 2005, diarrhea in past two weeks was associated with a lower mean HAZ score while in the 2000 analysis, maternal BMI was positively associated with HAZ score and presence of an improved latrine (pit latrine with or without slab and all other forms of improved latrines) was significantly and positively associated with HAZ score. The latter was not significant in any of the other survey years.

Quality and quantity of food has also been implicated as factors that are likely to affect linear growth. A cross sectional study conducted in the Dodota-Sire district to estimate the level of malnutrition and identify factors associated with stunting in breast fed infants aged 5-11 months found that infants fed 3 or more times, consuming more than 600 ml/day of cow's milk in addition to cereals and/or legumes had higher length-for-age Z-scores than those fed less frequently, or consuming less food, or not consuming cow's milk (13). Work conducted in West Gojam zone in Northern Ethiopia has found main contributing factors for under five stunting to be sex of the child, child's age, diarrhea episodes, deprivation of colostrum, duration of breastfeeding, pre-lacteal feeds, type of food, age of introduction of complementary feeding and method of feeding (17). We conducted analyses to examine variation in dietary pattern by region and by risk of being stunted. A frequency analyses shows that a large majority of Ethiopian infants and young children consumed grains, roots and/or tubers (71%), but other food groups were much less common, dairy being the next most consumed (30%). Consumption of dairy and other fruits/vegetables was negatively associated with being stunted, while consumption of grains, roots and/or tubers was positively associated with stunting. Children who consumed dairy in the past 24 hours were less likely to be stunted (OR=0.72); those who consumed grains, roots and/or tubers and legumes were more likely to be stunted (OR=1.52 and 1.35, respectively). Dairy was the most common animal source food but was consumed in low amounts in Tigray, Amhara and Bishangul-Gumuz (10-20% of children). In most regions, less than 2.5 meals and less than 2 groups were consumed by infants aged 6-24 months. Regions with higher dairy consumptions are more likely to have lower rates of stunting (Figure 13). Stunted children were likely to report consuming more meat but the association was not significant, the numbers of children consuming meat were small (5%) and the findings were inconsistent across regions (Tables 11-14).

A key factor associated with stunting in recent literature has been exposure to open defecation. Spears, for example, with a similar analytical framework has shown that over half of stunting can be attributed to open defecation (16). A series of analyses were conducted to examine the association of water and sanitation variables with the risk of being stunted. There are some associations with improved facilities in Addis Ababa, Amhara, Somali region and Affar but the findings are varied. Furthermore, our regional analysis of relationship between open defecation and risk of being stunted shows that while open defecation can explain 29%

of the variation in stunting and by itself is a significant predictor of stunting, incorporating other predictors in a step wise fashion first adding wealth index and then maternal height removed the significance. Similarly the presence of an improved latrine was significantly associated with a reduced risk of stunting, and the significance was retained when wealth index was added to the model - however it was lost when maternal height was added into the model. Wealth is likely associated with a number of factors unmeasured by the DHS survey, such as hygienic conditions, sanitary behaviors and possibly safer food and water, as well as education and other relevant factors, and thus this set of findings is of great interest. A model incorporating open defecation, wealth index and maternal height explained 71% of the variation in stunting across the various regions observed in the three survey years (Figure 14 and Table 15).

While there is considerable variability in the factors across years, age groups and regions, there are some key predictors that are common across the survey years. We conclude that the predictors of stunting across children under five years of age include age, sex, wealth index, birth size, maternal education (in older children), maternal height, maternal BMI and diarrhea in the preceding two weeks. Common predictors of stunting among all three survey years included age, sex, maternal education, birth interval, birth size and maternal height, while the factors associated with stunting that were unique to 2011 included maternal BMI and wealth. The association with breastfeeding after the age of 6 months may be an indicator rather than a cause of stunting.

There is some evidence of an effect of dietary patterns and practices (in younger age groups), and the presence or absence of good water and sanitation practices and facilities. In particular these include positive benefits accruing to the consumption of dairy, fruit, and vegetables. There was an increased risk of stunting associated with the consumption of grains, roots, and/or tubers, and with legumes. Some of these effects appear to be region specific and our interpretation must be constrained due to sample size restrictions.

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