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Research Article

Anthropometric Assessment of Adolescent Nutritional Status in Two Drought-Prone Areas of Ethiopia

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ABSTRACT

Objective: The aim of this study was to assess the prevalence of undernutrition and associated factors among adolescents in two food insecure zones in Ethiopia.

Methods: Data were collected through a survey of 350 rural households from five districts using a multistage sampling design. Demographic, socioeconomic, and anthropometric measurements were collected from 1437 individuals. The nutritional status of a subset of this sample, adolescents aged 10 to 19 years, was analyzed using the World Health Organization (WHO) AnthroPlus software. Height-for-age Z-score (HAZ), and BMI-for-age Z-score (BAZ) were calculated to determine nutritional status.

Results: The prevalence of stunting (HAZ less than -2 standard deviations (SDs)) and thinness (BAZ<-2 SDs) were 18.4% and 15.0% respectively. Although these values are high by international standards, adolescents from the study population have relatively low rates of undernutrition compared to younger children from the same communities. Overall, undernutrition among adolescents was negatively associated with household access to irrigation and livestock holdings, but not with household size, farmland size or agroecology.

Conclusion: Expanding access to nutrition-sensitive small-scale irrigation, and enhancing asset-building interventions, may contribute to the reduction of adolescent undernutrition in regions susceptible to climate change.

Keywords: Undernutrition; Adolescents; Stunting, Thinness; Livestock holding; Irrigation; Drought; Ethiopia

INTRODUCTION

Adolescence is the stage of the human life course spanning 10 to 19 years and encompassing the transition from childhood to adulthood. Worldwide there are an estimated 1.2 billion adolescents, making the largest such cohort in history [1,2]. Although the highest number of adolescents live in Asia, Africa's youth make up nearly a quarter of the continent's population [2]. Adolescents, who will become the citizens, workforce, and leaders of tomorrow, have critical nutritional requirements if they are to maximize their growth, development, and productivity [1]. Adolescence is often considered the healthiest developmental phase, as compared to childhood and adulthood, thus, it has attracted little attention from research, policy and development spheres [3]. Both maternal and paternal under nutritions have been shown to negatively affect the developmental trajectories of the next generation [4,5]. Specifically, malnourished adolescent mothers are more likely to give birth to children that suffer from low birth weight, stunted physical and cognitive development, reduced physical and economic capacity, as well as an increased risk of morbidity and high mortality [4-8]. The rapid growth and cognitive development associated with adolescence requires a higher amount of adequate nutrition to

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realize one's growth potential and prevent the intergenerational effects of undernutrition for females during pregnancy [9-11]; thus adolescents are especially vulnerable to undernutrition.

The key role that well-nourished adolescents will play in future generations, and the growing number of adolescents in the developing world, have attracted the attention of global stakeholders in research, policy, and practice [12-14]. As a result, several global initiatives, e.g., "the Global Strategy for Women's, Children's and Adolescents' Health 2016-2030", have been designed to promote research, policy, and programs that emphasize adolescent nutrition and health [3]. Healthy adolescence may also provide the opportunity to accelerate progress and advance human potential [3]. Although still debated, an increasing number of studies are showing that one can rebound or recover from childhood stunting during the adolescent years [15]. In other words, adolescence may be a last window of opportunity for the catch-up growth of undernourished children, especially in low and middle-income countries such as Ethiopia, where childhood undernutrition is widespread [16,17].

Globally, the highest prevalence of underweight children and adolescents are found in South Asia and East Africa [18]. In countries such as Ethiopia, the undernutrition rates for adolescents are high and 29% of females and 59% of males aged 15-19 years are underweight [19]. As recently as 2016, it was determined that Ethiopia has the lowest average BMI-for-age for both sexes in the world [18]. According to the 2016 Ethiopian Demographic and Health Survey (EDHS), rates of undernutrition of children under five remain among the highest in the world [19].

The Ethiopian Government has committed to addressing malnutrition by signing several international declarations related to nutrition, and by developing nutrition-related policies, strategies, and programs such as the National Nutrition Program (NNP) [20,21]. Furthermore, multiple international institutions and NGOs support or implement various nutrition-related programs and projects across Ethiopia, such as the Productive Safety Net Program (PSNP) [22]. These and other concerted efforts have improved nutrition and health for mothers and children through nutrition-specific, health-related interventions such as the provision of deworming tablets, vitamin A, and iron supplements [21]. Between 2000 and 2011, these efforts significantly reduced the prevalence of stunting and underweight children, including cutting child mortality by half [23]. However, the sustainability of these interventions is impossible if the underlying factors have not been addressed, and at present, 59% of adolescent boys 15 to 19 years of age are considered thin [19]. Thus, the need to develop sustainable nutrition-sensitive interventions is an urgent one [24], but this requires the simultaneous consideration of the social dimension as childhood and adolescent undernutrition are rooted in poverty, food insecurity, gender inequity, and lack of access to health, education, and other services [25-26].

Due to local and global initiatives and commitments, researchers and stakeholders are giving their increased attention to Ethiopian adolescents; however, the studies tend to be descriptive and less accessible to policy makers and practitioners [25]. Furthermore, the focus has been primarily on girls, urban, peri-urban, and student adolescents, due to the ease in locating large numbers of girls in one place, the school. This is true despite the observation that fewer than 10% of adolescents, especially girls, attend high schools in rural Ethiopia [19]. The present research contributes to the literature by focusing on rural households and including both male and female adolescents. Specifically, the aim of this study was to assess the prevalence of under nutrition and associated factors in two drought-prone areas of Ethiopia to serve as baseline information for future interventions.

METHODS

Study sites

This research was undertaken in East Hararghe Zone of the Oromia Region, and in the South Wollo Zone of the Amhara Region in Ethiopia (Figure 1). The two zones were selected for multiple reasons; both have agricultural universities that were willing to participate in a long-term, collaborative research project, and both are located in drought-prone zones with some of the most chronically food insecure areas in the country. South Wollo, for example, is within the region of Ethiopia known as "the buckle of the famine belt" [27].

A small-scale subsistence, mixed farming-system that integrates

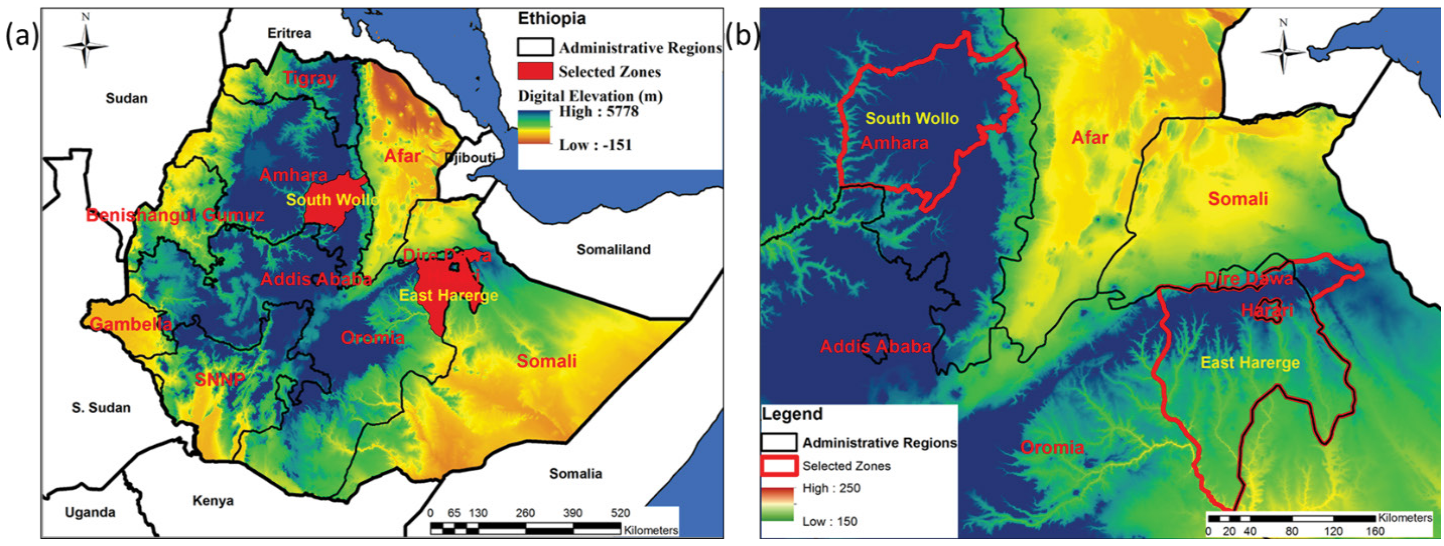

Figure 1: Map of Ethiopia showing the study areas.

crop and livestock production characterized the agriculture in both regions. Nearly all households owned some arable land, although the average landholding was just below one hectare. Sorghum (*Sorghum bicolor*), barley (*Hordeum vulgare*), maize (*Zea mays*), *teff* (*Eragrostis tef*), and wheat (*Triticum aestivum*), made up the main staple crops, although pulses such as beans (*Vicia faba*), peas (*Pisum sativum*) and lentils (*Lens culinaris*) were also common. Vegetables and cash crops, for example coffee (*Coffea arabica*) and *khat* (*Catha edulis*), were grown primarily as cash crops for generating income. About one third of the households had access to small-scale irrigation, primarily to produce vegetables and cash crops for the market. Finally, livestock provided nutrition in the form of meat, dairy, and eggs and, income through sale of livestock or livestock products enhanced social status. Thus, livestock assets are often used as proxy indicators of wealth. Because smallholder farmers typically own multiple species of animals, including cattle, sheep, goats, horses, donkeys and chickens, livestock holdings were measured in tropical livestock units (TLU). TLU were calculated based on species and age-specific factors developed for sub-Saharan Africa [28]. This index describes livestock biomass across species, with a single indicator, and summarizes the total amount of livestock owned by a household. The use of the TLU enables comparison between households, within and across different regions, and irrespective of the types of animal species owned [29].

Both study areas have comparable population sizes, with about 2.7 million living in East Hararghe [30] and 2.5 million in South Wollo [31]. However, the zones are ethnically different; East Hararghe is overwhelmingly (96.4%) Oromo, while in South Wollo, 98.6% of the population self-identify as Amhara. The rural populations in both regions are predominantly Muslim. Two districts from East Hararghe – Fedis and Haramaya – and three districts from South Wollo – Dessie Zuria, Kalu, and Tehuledere – were the focus of this study.

Research design and sampling

A cross-sectional, mixed methods approach was used to collect data on demographic and socioeconomic conditions, farming practices, and access to irrigation in the five study districts (woredas) between June and July 2010 and from June 1 to August 3, 2011. A multistage sampling design was employed, stratified by major agroecological zones. Despite cultural and agroecological differences, the two study areas are both characterized by (a) rain-fed, mixed crop-livestock farming systems, and (b) by high levels of food insecurity and under-nutrition [32,33]. Districts were purposively selected based on altitudinal variation that included lowland, midland, and highland areas to ensure that all major traditional agro-ecological zones were part of this baseline sample. For example in South Wollo, the three districts selected were Dessie Zuria (>2,500 m asl]), Telehudere (1,800–2,500 m asl), and Kalu (<2,000 m asl). Within each district, three to seven rural subdistricts (known as kebeles and the smallest administrative unit) were selected in consultation with local university faculty, district officials, and extension workers.

Households within each sub district were randomly selected using household lists provided by the district-level agricultural offices as sample frames. If members of the selected households were not available during data collection, the household in closest proximity was selected. A total of 340 households made up the final sample for the household survey, with 192 from Eastern Hararge and 148 from South Wollo.

Ethics

The University of Nebraska Institutional Review Board reviewed and approved the study protocol and all supporting documents (IRB Approval #: 20100710992EP). The proposal was then approved by Haramaya University in Eastern Hararge and Wollo University in South Wollo. Before the research was implemented in the field, the objectives of the study were explained to and permission was obtained from district and sub district officials.

The purpose of the study, the use of codes to ensure the confidentiality of personal information and responses, and the voluntary nature of participation were explained to each household head as well as other members of the household. Verbal consent to participate in the study was obtained, and assurance that participants could withdraw at any time without penalty, was provided to the household head before the interviews and anthropometric measurements were conducted.

Data collection and analysis

Household surveys and anthropometric measurements were taken for 1437 individuals. Nine enumerators from each region, organized into three teams, collected the data. All enumerators were junior faculty who spoke local languages, had familiarity with the communities under study, and were recruited from their respective universities (Haramaya University in Eastern Hararghe and Wollo University in South Wollo). Enumerators were trained by principal investigators to conduct the anthropometric measurements, dental assessments, and household surveys. Senior faculty from Haramaya and Wollo Universities supervised the data collection process. Structured questionnaires were prepared in local languages, 'Oromiffa' in East Hararghe and 'Amharic' in South Wollo. The data collection protocol was pre-tested in three villages in Eastern Hararghe and three villages in South Wollo, representing three and four percent of the study households respectively. The questionnaires were then revised for clarity. Information from the pre-test was not used during data analysis. Data were collected in the field using a pencil and datasheet, and entered into excel by enumerators. Principal investigators cleaned and analyzed the data.

Height was measured with the Perspective Enterprises Portable Measuring Stadiometer. All participants removed shoes and head cover, and were asked to place their heels at the base of the stadiometer prior to being measured. Mid-upper arm circumference (MUAC) was assessed using the Perspective Enterprises circumference measuring tapes (Perspective Enterprises, Portage, MI) on bare upper arms. Standing height, MUAC, and arm-span were measured to the nearest 0.01 cm, while weight was measured to the nearest 0.01 kg using The Seca 869 (Seca®, Chino, USA) electronic scale. Each height and weight measurement was taken twice and the digital scale was recalibrated before each measure. Anthropometric indices were calculated using the WHO AnthroPlus software. Z-scores for height and BMI were calculated based on age and gender. Stunting was defined as height-for-age (HAZ) Z-scores less than negative two standard deviations (-2 SDs) from the median of the WHO Reference 2007 for children 5-19 years. Similarly, underweight and thinness were defined as weight-for-age (WAZ) and BMI-for-age (BAZ) Z-scores less than -2 SDs

respectively [34]. Values of Z-scores between -3 and -2 SDs were defined as moderate, and Z-scores lower than -3 SDs were classified severe. The relationship between factors that might influence the prevalence of undernutrition, such as sex, zones, district, agroecology, landholdings, household size, frequency of reported illness, livestock holdings, and household access to irrigation were explored using SPSS (IBM SPSS Statistics for Windows, Version 25.0. Armonk, NY: IBM Corp.).

T-tests, bivariate correlations, chi-square tests, and multinomial and binary logistic regressions were performed to assess the association between nutritional status indicators and independent factors, such as prevalence of stunting and thinness. Variables with p-values of less than 0.3 from the exploratory tests were included in the binary logistic regression. The regression analysis resulted in adjusted odds ratios (AOR) with 95% confidence intervals (CI). A p-value of 0.05 or less was considered statistically significant. Hosmer-Lemeshow was generated to assess goodness-of-fit of the regression model. Due to the adolescent growth spurt and the associated problems of weight-for-age measurements, nutritional status analysis is based on HAZ and BAZ in this report.

RESULTS

The overall prevalence of stunting and thinness among adolescents in Eastern Hararghe and South Wollo was 18.4% and 15.0% respectively. Among the 244 adolescents in this study, the mean age was 13.07 years with a range of 10 to 19 years. About 76% of females, and 78% of males, identified themselves as single (not married), with the remaining 23% being married, divorced, or widowed (Figure 2).

Adolescents from the study area exhibited a relatively high prevalence of undernutrition. For example, prevalence of stunting ranges from 14% in Haramaya to 24% in Kalu district. The two lowland woredas, Kalu and Fedis, have higher numbers of undernourished adolescents compared to the other districts. However, variation in the prevalence of stunting across woredas was not statistically significant (X^2=2.2, df=4, p=0.71). The prevalence of undernutrition was relatively better for female adolescents. By contrast, the prevalence of stunting was almost identical for both genders, while the prevalence of thinness (BAZ less than -2 SDs) was considerably higher for males. Nevertheless, the variation in thinness between male and female adolescents is only marginally significant (p=0.07). As shown in Table 1, thinness did not vary significantly for the rest of the independent variables considered.

Neither zones/regions, districts, agroecology, farmland size, household size, nor frequency of sickness appeared to have significant association with the prevalence of stunting or thinness among adolescents in the study areas. Despite the lack of statistical significance, adolescents from households in the lowland districts (Fedis and Kalu) and the lowland agroecological zone had a higher prevalence of stunting.

Two independent factors, household-level livestock holdings and access to irrigation, were significantly associated with chronic undernutrition among adolescents (Table 1). Livestock holdings, measured in TLU per capita, were negatively associated with prevalence of stunting in the study area. Adolescents from households with higher livestock holdings were more likely to be within the normal height-for-age range (AOR 2.13; 95% CI 1.08-4.21; p=0.03). Although BAZ was not significantly associated with livestock holdings, adolescents from households with fewer holdings showed higher prevalence of thinness.

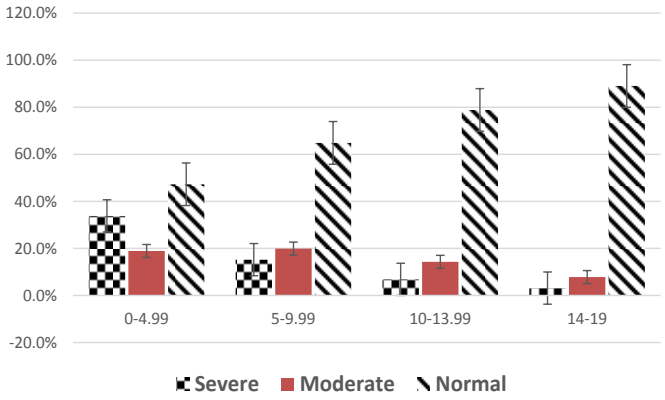

Figure 2: Prevalence of stunting by age groups.

Table 1: Prevalence of stunting, and thinness among adolescents in the study areas.

Variable	Values	Stunting (%)	P-value	Thinness (%)	P-value
Sex	Male	18.5	0.95	19.3	0.07
	Female	18.3		10.7	
Zones	Hararghe	17.0	0.59	14.9	0.55
	Wollo	19.7		15.1	
District	Fedis (H)	21.4	0.71	16.7	0.99
	Haramaya (H)	14.3		13.9	
	Dessie (W)	15.8		16.2	
	Kalu (W)	23.9		15.2	
	Tehuledere (W)	18.6		14	
Agroecology	Highland	15.8	0.42	16.2	0.90
	Midland	15.9		13.9	
	Lowland	22.7		15.9	
Farmland size	Low	21.0	0.17	15.3	1.0
	High	13.8		14.9	
Household size	Low	17.2	0.36	13.6	0.72
	High	12.9		16.2	
Freq. of Sickness	No	18.5	1.0	13.8	0.57
	Yes	18.3		17.3	
Livestock Holdings	Low	22.7	0.09	17.2	0.38
	High	13.6		12.9	
Irrigation	Yes	9.8	0.01	13.4	0.71
	No	22.9		15.8	

(H) East Hararghe; (W) South Wollo

Household access to irrigation was significantly associated with linear growth. Adolescents from households with access to irrigation were more likely to exhibit a normal height-for-age Z-score (AOR 2.47; 95% CI 1.08-5.67; p=0.03). Although BAZ was not significantly associated with access to irrigation, adolescent from households without access to irrigation showed a higher prevalence of thinness.

DISCUSSION

Mirroring the recent global interest in adolescent nutrition, an increasing number of studies are being conducted in different parts of Africa to assess the nutritional status of adolescents and

the associated factors. One common finding from these studies is a high prevalence of undernutrition among adolescents in Ethiopia as compared to other parts of the world [15,35-43]. Because this study was conducted in drought-prone areas, it was not surprising to find relatively high rates of chronic undernutrition among adolescents, e.g., one in four adolescents are stunted in the South Wollo's Kalu district. In fact, three of the five study districts, including Kalu, are targets of PSNP, although two of them, Fedis and Kalu, still exhibit the highest child and adolescent undernutrition. Nevertheless, the prevalence of undernutrition among adolescents in this study was lower than that of younger children in the same area, where it reached as much as 50% [19]. In fact, prevalence of stunting steadily declines as children pass from early (5 to 10) to middle (10 to 15) and late adolescence (15 to 19) as depicted in Figure 2. The pattern of that decline in the prevalence of undernutrition was similar for both girls and boys.

Compared to studies of adolescent nutritional status in other parts of Ethiopia, the prevalence of stunting in the study area was within the range of variation exhibited in other parts of the country. Regarding HAZ, adolescents in the study districts exhibited relatively better nutritional status compared to studies conducted in Amhara and Tigray regions, but were worse compared to other regions of the country (Figure 3).

Similarly, the prevalence of thinness in the study area is comparable to that found in other studies on adolescent nutrition in the rural Amhara region [41] and in other urban environments, such as the towns of Adama [39] and Jimma [35] in Oromia region. However, our study areas, as well as those in other published works (depicted in Figure 4), have a considerably lower prevalence of thinness compared to the rural Tigray region [43]. Other comparative datasets also indicate that overweight or obese adolescents are rare in rural households. Adolescents from only high socioeconomic households and urban environments exhibit overweight and/or obesity characteristics. Towns such as Jimma [44] and Adama [39] demonstrate the beginning of the 'double burden' of malnutrition, where prevalence of both overweight and underweight individuals co-occurs in the same community [45]. By contrast, overweight and/or obesity is not yet an issue in rural Ethiopia [41,43], including the areas in this study [19].

Although studies assess different independent factors, the most common factors that have been positively associated with adolescent nutrition are high socioeconomic status, often measured through income, occupation, assets, and level of education [35-37,39,42,44].

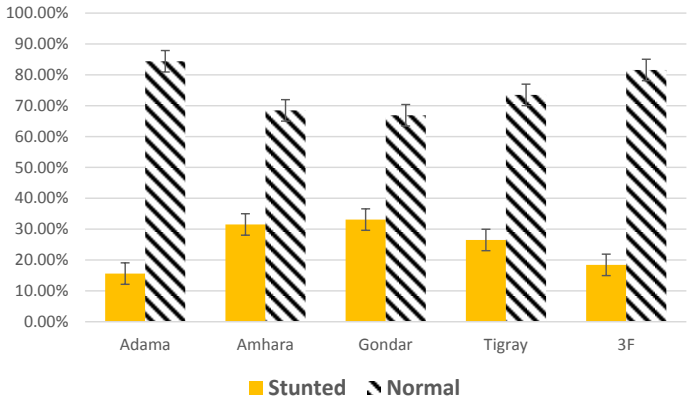

Figure 3: Prevalence of stunting from different studies compared to this study (3F).

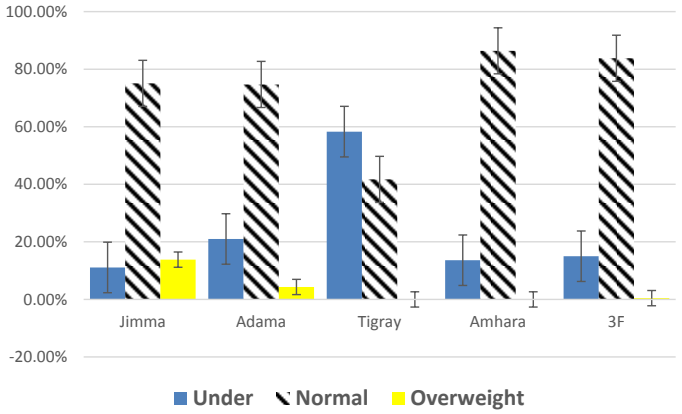

Figure 4: Prevalence of thinness across studies.

A number of studies also demonstrate an association between the prevalence of undernutrition among adolescents and food security, including dietary diversity, and frequency of food intake [35,38,39-42,46].

Although not always consistent [47], several studies in Ethiopia [36,39,44] and elsewhere [48,49], have indicated that parents' educational status, especially that of the mother, has a significant impact on nutritional status of children and adolescents. However, in this study, because only about 10% of adults (greater than 20 years of age) have any level of formal education, nutritional status was not associated with the educational level of parents. Furthermore, although about 43% of adolescents have received some level of formal education, prevalence of chronic undernutrition was not significantly associated with schooling. This might be related to the fact that only 5% of the adolescents in the study area had attended high school, and even in this case, nutrition education might not be a strong component of the Ethiopian curriculum [50].

Different from other studies [42,51], household size was not significantly associated with the nutritional status of adolescents, although households with more members exhibit higher prevalence rates of severe undernutrition (Table 1). Household size in this study was determined using the number of individuals available at the household during anthropometric data collection. This may systematically underestimate household size, although efforts were made to take measurements of individuals missing at the first attempt at a later time or on a different date. Thus underestimating may be the reason for the lack of a significant association between household size and prevalence of undernutrition in this study.

The prevalence of stunting was negatively correlated with livestock holdings in the assessment of adolescent growth. A higher number of per capita livestock holdings may directly affect the nutritional status of adolescents as they provide a regular supply of animal source protein (dairy products, meat, and eggs) and both supplement and diversify a diet heavy in plant-based staples [35,39,41,52,53]. Higher livestock holdings may also affect adolescent nutritional status indirectly, through improved access to food, especially during seasonal fluctuations in grain availability as is common in Ethiopia. Approximately 50% of the households in the study area sell livestock, or livestock products, to purchase additional food. Often, those purchased foods are different from the ones produced by the household, increasing dietary diversity, and enhancing the nutritional status of their members, including adolescents.

Despite the complex association in this study between the access

to irrigation and nutrition [24,54-56], access to irrigation appeared to improve adolescent nutrition. Although irrigation in the study areas is primarily used for the production of cash crops [57], the revenue generated from cash crops is often used for purchasing food (Beyene, et al. unpublished data) during the 'lean season' [58], when food stocks from the household's own production is depleted or to purchased food not produced in their own farm. Overall, access to irrigation increased both income and the production of food crops [55,57], which may directly and/or indirectly lead to improving the nutrition for adolescents. Crops produced using irrigation, such as vegetables and fruits, can enhance household nutrition, however, they are primarily produced for markets. Also, the highest income-earning irrigated crop, khat, appears to have mixed associations with nutrition [59,60], perhaps due to its stimulant properties and addictive nature, among other factors [61]. Nevertheless, its market value has become so high, farmers are replacing their coffee plantations with khat in Eastern Ethiopia [62].

Adolescent nutritional status, as measured through anthropometry, can be enhanced through different pathways, such as homestead crop production and cultivating diversified crops [54], including participation in irrigation activities to earn income. The latter may be a critical factor, as household access to irrigation did not significantly reduce overall undernutrition of under-five children in the same study area (Beyene et al. unpublished report). Even the health of livestock is enhanced by access to water, consequently, irrigation sources can affect more than just crop production. More research is needed to understand the specific pathways by which access to irrigation influences child, adolescent, and adult nutrition in different parts of Ethiopia.

CONCLUSION

Although the cross sectional nature of the study limits strong conclusions, it appears that development interventions that support households building their livestock assets may contribute to improving adolescent nutritional status in rural Ethiopia. Similarly, household access to irrigation may enhance adolescent nutrition, although the magnitude of improvement is relatively low. The current concerted effort, by the Ethiopian Government and NGOs, to expand small-scale irrigation, can have a significant and positive impact in reducing children and adolescent growth retardation if small-scale irrigation projects are designed to include nutritional outcomes as one of their objectives.

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CONFLICTS OF INTEREST

The authors declare no conflict of interest.

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