The Shape of Things to Come? Household Dependency Ratio and Adolescent Nutritional Status in Rural and Urban Ethiopia

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Abstract

Several related demographic trends are occurring in developing countries: youth comprise a large portion of populations, fertility rates are declining, and urban dwellers are increasing. As fertility rates decline and populations age, the decline in the ratio of young dependents to working age adults is expected to free up household resources, which can be invested in human capital, including youth nutritional wellbeing. We test this hypothesis in a sample of youth ($n = 1,934$) in Southwestern Ethiopia. Multiple measures of achieved growth and nutritional status are explored (weight, height, mid-upper arm circumference (MUAC), body mass index (BMI) and body mass index for age z-score (BMIZ), weight for age z-score (WAZ), and height for age z-score (HAZ)). In multivariable models controlling for the effects of income, age, gender, and youth is workloads, youth living in rural settings had significantly lower weight (1.24 kg lighter), MUAC (0.67 cm lower), BMI (0.45 BMI lower), BMIZ (0.27 lower), HAZ (0.14 HAZ lower), and WAZ (0.3 WAZ lower) than urban youth (all $P < 0.01$). Compared with youth in the lowest dependency ratio households, results show that youth in households with the highest dependency ratios were estimated to be 1.3 kg lighter, have 0.67 cm smaller MUAC, and BMI that was 0.59 lower (all $P<0.01$). Similar results were found for WAZ (0.21 lower) and BMIZ (0.36 lower). Youth height and HAZ were not associated with household dependency. These results may point toward increasing levels of human capital investments in Ethiopian youth as fertility levels decline and populations urbanize. Am J Phys Anthropol 144:643–652, 2011.

Keywords

dependency ratio; adolescents; nutritional status; human capital; demographic transition; Africa

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Currently there are more young people (aged 15-24 years) than ever before in the history of the world. This large cohort of young people is the result of the tremendous population growth that occurred primarily in developing countries during the 1950 - 1970s, although it continues in some countries today. During this period of remarkable growth many countries experienced annual growth rates of 2–4%. This growth led to the current large cohorts of young people that dominate the populations of many developing countries (UNFPA, 2003;

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Lam and Marteleto, 2008). Projections for Ethiopia, for example, indicate that by 2050 there will be nearly nine times as many young people as there were in 1950[1]. In many countries around the world, the absolute size of the youth cohort has or is near to reaching its peak. In contrast, many African countries will see the size of their youth population peak only after 2030 (Lam, 2006). At the same time as youth populations are continuing to grow, in many African countries fertility rates are declining. As fertility rates decline and population growth slows, elements of a demographic transition (Lee, 2003), the absolute size of the population will continue to increase because of population momentum (Rowland, 2003). Still, population growth will slow and this will lead to important shifts in the age structure of the population. An important consequence of declining fertility at the household level is a shift in the dependency ratio, or the number of consumers to producers. The ratio of young dependent household members to adult working age household members has long been used to measure the availability of household resources for investments in child health and wellbeing. High dependency ratios associated with high fertility in many developing societies have been viewed by development scholars and stakeholders as impediments to human capital formation. Thus, in settings where fertility rates have declined or are declining youth will increasingly find themselves in households with fewer siblings, and with less competition for familial resources (Bongaarts, 2001; Loyd, 2005; Lam and Marteleto, 2008).

The implications of these dramatic population-level shifts have not gone unnoticed by scholars and policy makers. Many have focused on the economic and financial implications of an aging population and the concomitant shifts in the ratio of elderly to working age persons (Lee, 2003; PRB, 2010). Others have sought to link population level shifts in dependency ratio to macroeconomic outcome. Bloom and Canning have suggested that the lower dependency ratios found in East Asia are responsible in part for the "economic miracle" and that high dependency ratios continue to contribute to sub-Saharan Africa's "economic debacle" (Cited in von Braun et al., 2009: 18). Along these same lines, some have used longitudinal data to show that shifting dependency ratios are associated with lower per capita and household poverty (Paes de Barros et al., 2001) while others still have linked declining dependency ratios to improving rates of school attendance (Lam and Marteleto, 2005).

Less well studied are the consequences of shifting population age structures for other measures of human capital at the individual-level, including nutritional status. In theory there should be many individual and household level implications. This is because age structure ultimately determines household dependency ratios, which are likely critical determinants of multiple facets of the household ecology. High dependency ratios within households mean that labor is in high demand, as the few work to produce and meet the needs of many. All else equal, high dependency ratios should indicate household strain and low dependency ratio should indicate less strain, reduced labor demands and greater per capita familial resources. To the extent that the household is the central unit of consumption and production, as it is often taken to be in anthropological studies (Netting, 1993), households that are strained both in terms of income and labor should be less efficient at producing health. One prediction is that, all else equal, households with higher household dependency ratios should have children with poorer nutritional status (e.g., Pelto and Pelto, 1984). Studies do tend to show that high dependency ratio is associated with worse household and infant and young child outcomes.[2] We know of no studies that have examined the relationship between household dependency ratio and youth nutritional outcomes in a low-income setting. This gap may be due in part to the paucity of studies of

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[1]United Nations, Department of Economic and Social Affairs, Population Division, World Population Prospects: The 2008 Revision, New York, 2009 (advanced Excel tables).

youth nutritional status, and those that are available have often focused specifically on females and migration and socioeconomic status. Still, there are hints in the literature of a relationship between nutritional status and household composition. Leslie and Pawloski (2009), for example, examined female nutritional status in Mali and found that female youth living in households with more women and servants were associated with better nutritional status. They suggest that this relationship may be due to lower dependency ratios with "more adults shar[ing] the workload, resulting in less average work per person." (p. 4). They point out that their results highlight the importance of household structure and the potential unimportance of standard measures of socioeconomic status. Although youth nutritional status is, relative to children, understudied, there has been some research examining the association between measures of nutritional status and household socioeconomic status, place, youth migration status, and energy expenditure (Simondon et al., 1998; Benefice et al., 1999; Garnier et al., 2003;) often, but not always, showing that urban youth with low workloads and living in high socioeconomic status households have higher nutritional status. Much of this work has focused on women, although again it is important to reiterate that there is a dearth of material on youth nutritional status.

Given this background, the article aims to make several contributions. First, we aim to describe the nutritional status of youth in one location in Ethiopia and test the hypothesis that indicators of nutritional status among Ethiopian youth will be lower than age and sex matched peers in the USA. This should provide some insights into the health and wellbeing of a sample of the massive cohort of youth in low-income countries. Second, because population age structure affects the dependency ratio, which in turn affects the behavioral ecology of households, the hypothesis that household dependency ratio is associated with indicators of nutritional status is tested, while controlling for other potential determinants of nutritional status such as individual characteristics and household income, youth workloads, and urban or rural locale. This should provide insight into the individual level consequences of population level shifts in dependency ratio. We also assess a suite of alternative hypotheses regarding household type and nutritional status. Finally, the associations with urban dwelling are noted because of the urban revolution that is now occurring (Montgomery, 2008).

METHODS

Sample

The study data come from the town of Jimma, which has a population of 120,000 (CSA, 2007), and surrounding towns and rural communities in the Oromia region of Ethiopia. There are compelling demographic reasons to examine youth outcomes in Ethiopia. The demography of Ethiopia is similar in many ways to other low-income countries that are moving through a demographic transition. The 1960s were marked by under-5 mortality rates that often exceeded 250 deaths per 1000 live births but that were beginning to decline rapidly. Indeed, while still shockingly high, by 2005 the under-5 mortality rate was estimated at 164/1000 live births. Total fertility remained remarkably stable at 7 or greater until the 1980s and then declined to 6.4 in 1990, and to 5.4 in 2005 (CSA 2006). The combination of high fertility and declining mortality rates was rapid population growth. Per annum rates of population increase of 2–3% have been common for most of the last fifty years, with Ethiopia's population growing from around 18 million in 1950 to approximately

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[2]Concern over household dependency ratios has increased not only because of global demographic shifts but also because of the impact of the HIV/AIDS epidemic and households with orphans Madhavan S, Schatz E, and Clark B. 2009. Effect of HIV/AIDS-related mortality on household dependency ratios in rural South Africa, 2000-2005 Population Stud 63(1):37-51, Miller CM, Gruskin S, Subramanian SV, and Heymann J. 2007. Emerging health disparities in Botswana: examining the situation of orphans during the AIDS epidemic. Social Sci Med (1982) 64(12):2476-2486.

84 million in 2010.[1] Similar patterns of declining mortality, high and then declining fertility marked many developing countries over the last 50 or so years. The result of this period of growth is the large current cohort of young people, many of whom are the "grandchildren of the population explosion" (Lam, 2006). The more recent decline in Ethiopian fertility has led to smaller family sizes, and households that tend to have markedly lower dependency ratios than in the past.

The data used for this study come from the baseline round of the Jimma Longitudinal Family Survey of Youth (JLFSY) which was designed to follow adolescents through time to examine the social and biological determinants of early life trajectories. The JLFSY study area includes the regional city of Jimma Town, three nearby towns, and the rural areas surrounding the towns. The three towns and surrounding rural areas represent diverse agro-ecological zones. A self-weighting multistage, stratified sampling design was employed in the large urban town of Jimma. In the first stage neighborhoods were randomly selected from each of three larger administrative divisions, and then households were randomly selected from each of six neighborhoods. In the three smaller towns and nine rural areas a simple random sample of households was drawn. In the six urban neighborhoods complete lists of all households were compiled through a street-by-street enumeration of all households. In the towns and rural areas it was determined through random checks in the field that the household lists maintained by the local authorities were up-to-date and complete. These lists provided the sampling frames for the study. Up to one adolescent male and one adolescent female ages 13-17 were included in the study for adolescent interviews. In households with more than one eligible adolescent male or female, a random selection procedure (Kish Table) was used to randomly select on of the youth for inclusion in the study. A total of 2,084 youth was interviewed. The current analyses utilize data for 1,943 for whom complete body measurements were collected. All adolescents provided consent and study procedures were approved by Jimma University and Brown University. Analysis was carried out on de-identified data.

Dependency ratios

To examine the potential impact of declining child dependency ratios, several different measures of dependency were calculated. Typically the household dependency ratio is calculated as the ratio of nonworking age individuals to working age individuals. Working age individuals or producers are often defined as being 15–64 years of age, while those less than 15 years or older than 64 years are considered consumers (Rowland, 2003). Clearly these cut-offs are influenced by recent, Western labor and legal practices and do not reflect the exact age-specific productivity profiles in Ethiopia. Based on anthropological data, one could make a strong claim that in many developing country settings, youth under age 15 years engage in productive household and nonhousehold work (Weisner and Gallimore, 1977; Nag et al., 1978; Kramer, 2005). Because of the importance of youth in unpaid household work, even accurately reported age-specific earnings alone would disallow the creation of an accurate dependency ratio. There are also theoretical concerns at the other end of the age spectrum and in the absence of data on age-specific rates of disability and productivity the cutoff of 65 years like 15 years, appears somewhat arbitrary. Recently Harwood et al. (Harwood et al., 2004) used 601 years as a cut-off to calculate global elderly dependency ratios based on the distribution of disability as observed in the World Health Organization's World Health Survey. There are also methodological problems when calculating dependency ratios, especially in populations or cohorts that have limited or no knowledge of their birth year. This can lead to "age heaping" or clustering of ages at specific numbers. Heaping can clearly influence the results of dependency ratios calculations.

To address these methodological and theoretical issues several different dependency ratios were calculated. The household dependency ratio was calculated as the number of children

(0–11 yrs, 0–12 yrs, 0–13 yrs, 0–14 yrs) and elderly (>60 yrs, >64 yrs) divided by the number of working age adults (12–59 yrs, 13–59 yrs, 14–59 yrs, 15–59 yrs, 12–64 yrs, 13–64 yrs, 14–64 yrs, 15–64 yrs). In practice, the results are qualitatively similar when different dependency ratios are used so we report results for a dependency ratio based on a working age population of 15-59 years. All ratios are multiplied by 100 and can be interpreted as the percentage of household members who are dependents. Higher values indicate more consumers relative to producers and therefore greater household strain. For the sake of presentation, results are occasionally presented comparing households of the highest and lowest dependency ratios, defined as the lower and upper quartiles.

Household and individual characteristics

Predictor and control variables included age, gender, place of residence, workloads, and household income (in Ethiopian Birr/household/week; 1 USD = ~10 Birr). Age was reported in full years. The household income variable was created by summing across the weekly incomes reported for all members of the household. This variable was included because it is a measure of socioeconomic position and may indicate differential abilities to produce health at the household level, through more or higher quality foods, healthcare, or more hygienic environments. Domestic workloads were measured by asking youth respondents on how many days in a typical week they engaged in a variety of nonpaid work tasks. These tasks included caring for animals, working on farm activities, fetching water and fuel, washing clothes, cooking, engaging in childcare, pounding or grinding grain, and engaging in heavy labor tasks. Activities were then summed and standardized so that individual workloads ranged between 0 and 100; with 100 representing an individual who undertook every activity everyday over the last week. Workload was included as a variable of interest because of its relationship with energy expenditure, which in turn influences nutritional status. Several authors have implicitly or explicitly linked increasing female workloads with lower nutritional status, so we tested for both main effects of workloads and interactions with gender (Aiken et al., 1991). This is an admittedly crude measure but is the only measure that exists in the dataset.

Anthropometry

Immediately following face-to-face interviews, adolescents were weighed and measured using standard techniques (Frisancho, 1990). To minimize inter-measurer variation, all interviewers had undergone extensive training and exercises prior to the initiation of the survey; these exercises revealed high inter-measurer reliability. Weight was measured in kilograms using portable Seca scales and subjects wore minimal clothing and no shoes. Height was taken to the nearest centimeter on a portable stadiometer with respondents encouraged to stand tall and straight. Mid-upper arm circumference (MUAC) was measured in centimeters on the respondent's left arm at the midpoint between the olecranon and the acromion processes. The body mass index (BMI) was calculated as weight divided by height squared. The weight, height, and BMI data were plotted against age and sex matched data from the CDC and MUAC values were plotted against NHANES as presented in Frisancho (Frisancho, 1990). There is some controversy over the appropriate reference data for adolescents, especially in low-income settings and the value of working with cut-offs (Woodruff and Duffield, 2002; Cole et al., 2007; Leslie and Pawloski, 2009). We therefore work primarily with the continuous data rather than attempt to generate cut-offs. We converted weights and heights into weight for age, height for age, and BMI for age *z*-scores using the CDC reference data. Because the majority of youth reported only their year of birth, we randomly assigned months of birth to youth who did not provide a month of birth to calculate *z*-scores.

Statistical analysis

Descriptive statistics on key variables were computed to compare the Ethiopian sample with age and sex matched data from the CDC 2000 growth reference curves (Kuczmarski et al., 2002). The average values for weight (kg), height (cm), and body mass index (BMI) for each age group across the Ethiopian and USA samples were compared and visually inspected to assess where the Ethiopian data lay relative to the USA percentiles. We compared age and sex-specific MUAC curves with the NHANES data, as reported in Frisancho (1990). Within the Ethiopian sample we then carried out a series of multivariable regression models to examine the predictors of weight, height, MUAC, and BMI. Models were also fit to height for age zscores (HAZ), weight for age zscores (WAZ), and BMI for age zscores (BMIZ). In addition to control variables such as age (in complete years) and gender, measures of place, household size, household dependency ratio, household income, and youth workloads were entered as covariates. As per the introduction, we were particularly interested in the relationship between the household dependency ratio and nutritional status. An interaction term between gender and workload was included to examine gender specific effects of work. All the statistical analyses were carried out using R software.

RESULTS

Characteristics of the study population

The average age of youth was 14.8 years. There was no difference in the age structure of the male and female populations. The sample was divided nearly equally across the three different types of study area (rural, urban, semiurban).

Ethiopian youth compared against the CDC 2000 data

Females weighed on average 44.6 kg (SD 8.1, $n = 936$, Table 1), although this ranged from a mean of 37.2 (SD 6.4) among 13-year-old girls to a mean of 50.9 kg (SD 6.9) among 17-year-old girls (Table 1). As a whole, boys were significantly lighter than girls with a mean weight of 43.2 kg (SD 9.5), although this ranged from a mean of 34.6 (SD 5.6) for 13-year-old boys to 51.3 kg (SD 7.3) for 17-year-old boys; in the older age categories (16- and 17-year-olds) there were no differences in mean weights among males and females. Boys were significantly taller than girls ($P < 0.01$) across all age categories ($P < 0.05$) except age 13 years ($P = 0.16$). BMI was greater in females than males in all age groups ($P < 0.01$). Similarly, MUAC was significantly lower among males than females across all age groups ($P < 0.01$).

On average, Ethiopian males and females were significantly lighter than their age and sex matched peers living in the USA; 20% of the Ethiopian sample had a WAZ below −2. Females' weight tracked the 5-25th percentile, reaching the 25th percentile among the 15-year-olds, and hovered on or above the 25th percentile for the 16- and 17-year-olds. For the males, average weight was around the 10–15th percentiles. Males (26%) were more likely than females (14%; $P < 0.01$) to be underweight, defined as a WAZ $<−2$ SD. Youth from Ethiopia were also substantially shorter than their US peers when matched for age and sex; 14% of the sample had a HAZ $<−2$ SD below the reference median. The female Ethiopian sample hovered near the 25th percentile of the reference population and the heights of the male sample tracked the 15–25th percentiles. Males were more likely (16%) than females (12%) to have low HAZ ($P < 0.01$). Body mass index was substantially below the median CDC2000 value for most ages for the sample as a whole although female BMI generally lay between the 25th and 50th percentile whereas males BMI consistently lay between the 5th and 25th percentiles. Seventeen percent of the Ethiopian sample had a BMIZ of less than −2 SD. Males were more likely than females to have a low BMIZ (25% vs. 8%, $P < 0.01$). For

the females, BMI for age among the 13-year-olds was near to the 25th percentile and increased across each age group. Among the 17-year-olds, female BMI was near to the 50th percentile of the CDC2000 reference. Mid-upper arm circumference was below the NCHS reference median for both male and females samples.

Predictors of within sample variation

Next we explored the relative associations of respondent age, gender, household size and dependency ratio, income, workload, and location (urban, semiurban, and rural) on measures of weight, height, BMI, MUAC, WAZ, HAZ, and BMIZ. The aim here was to test for hypothesized relationships between household dependency and measures of nutrition wellbeing. Although there was considerable overlap, the household dependency ratio was greatest in the rural sites (116 SD 79), followed by the semi-urban sites (94 SD 81) and lowest in the urban sites (72 SD 70). Income and workloads followed a similar pattern. The household dependency ratio was positively associated with workloads ($r = 0.21$, $P < 0.0001$) and negatively associated with household income ($r = -0.14$, $P < 0.0001$); which is consistent with the general theory linking dependency ratios to household strain. Bivariate correlation analysis showed that household income was weakly and positively correlated with weight, height, MUAC, WAZ, HAZ, BMI, and BMIZ (all $P < 0.05$). Workloads were weakly and negatively correlated with weight, height, MUAC, and HAZ (all $P < 0.05$), positively with BMIZ ($P < 0.02$) and not WAZ and BMI ($P = 0.06$). In bivariate tests, rural youth had the lowest levels of nutritional status (i.e., HAZ, WAZ, BMIZ), and the lowest weight, height, and MUAC. Below the results of multivariable models predicting weight, MUAC, height, and BMI and WAZ, HAZ, and BMIZ are reported.

Adolescent weight increased with age, as expected, and boys were on average lighter than their female counterparts (Table 2). Youth living in rural settings were significantly lighter than their counterparts in semiurban and urban settings. Model predicted estimates of weight were approximately 1.2 kg lighter for rural youth than for urban youth. Youth living in households with greater reported income were heavier. Youth in households with incomes in the highest quartile had a model predicted weight 0.56 kg greater than youth in the lowest income households. Household size was not associated with weight but dependency ratio was: Household dependency was negatively associated with youth weight, suggesting that as dependency ratio increases, weight decreases. Youth in households with dependency ratios in the lowest quartile had a model predicted weight that was 1.34 kg heavier than the predicted weight of youth in households with dependency ratios in the highest quartile. Workload as a main effect was not a significant predictor of weight but the interaction between work index and gender was negative and significant, indicating that at higher workloads boys weighed somewhat less than expected. Results using WAZ as the outcome were qualitatively similar except that household size was a significant and negative correlate of WAZ (results not shown). Youth in the lowest dependency households had a model predicted WAZ that was 0.21 greater than youth in the highest dependency households (i.e., lowest dependency = -1.05 WAZ vs. highest dependency = -1.27 WAZ).

Measures of MUAC showed similar patterns as weight (Table 3). MUAC values increased with age and were generally lower among males. Relative to their urban peers, rural, and semiurban youth had significantly lower MUAC. Model predicted MUAC was about 1.4 cm smaller in rural youth than urban youth. Household income was positively associated with MUAC but this was not statistically significant (partial $P = 0.08$). Household size was not associated with MUAC but the household dependency ratio was negatively related to MUAC, again suggesting that as the dependency ratio increases, MUAC declines. Youth in households with dependency ratios in the lowest quartile had a model predicted MUAC that was 0.66 cm greater than the predicted MUAC of youth in households with dependency

ratios in the highest quartile (22.2 cm vs. 21.5 cm). Work index was not associated with MUAC as a main effect but again the interaction with gender was significant. Exploration of the interaction revealed a positive association between MUAC and work for girls but a negative association for boys.

The multivariable regression model predicting BMI showed statistically significant associations with age and gender (Table 4). BMI was greater among older individuals and was, controlling for other covariates, greater among women. Household income and household size were not associated with BMI but level of urbanization was: rural dwellers had significantly lower BMI than youth in semi-urban sites and urban sites. Model predicted BMI among rural youth was approximately 0.45 BMI lower than the model predicted BMI of urban youth. Household dependency ratio was negatively associated with youth BMI: youth BMI was significantly lower in households with higher dependency ratio. Youth in households with dependency ratios in the highest quartile had a model predicted BMI that was 0.45 greater than the predicted BMI of youth in households with dependency ratios in the lowest quartile (i.e., lowest dependency ratio households: 18.0 BMI vs. 17.5 BMI highest dependency ratio). Work index was not associated with BMI as either a main effect or an interaction. Results using BMIZ as the outcome variable were qualitatively similar to those using BMI (not shown).

Finally, predictors of height included age and gender with, not surprisingly, older youth and males being taller, controlling for other covariates (Table 5). There was no difference in heights between respondents in urban, semi-urban, or rural locales. Independent of other factors, households with higher incomes were associated with taller youth, while larger households were associated with shorter youth. The interaction between workload and gender was significant and suggested no relationship between workload and height among females but a slight negative relationship for boys. The household dependency ratio was not associated with youth height. Youth in households with the highest and the lowest dependency ratios had model predicted heights of 156 cm. Model results using HAZ as the outcome were qualitatively similar to those obtained from the height model except that urban youth had significantly greater HAZ scores than semiurban and rural youth (not shown).

Testing alternative explanations: Household composition or household type?

On the basis of behavioral ecology theory, we have argued that household composition drives levels of available resources, which in turn affects individual human capital formation, including the nutritional status of youth. An alternative hypothesis is that the dependency ratio tells us less about household composition and more about household *type* and the conditions that lead to household type, and that it is these conditions that are influencing nutritional status and body composition among youth. Households may take many different forms, all of which might affect the dependency ratio. Female headed households might be expected to have higher dependency ratios simply because there is no husband and the opposite may be true for polygynous households. Other households may be multigenerational or multifamilial. Households may include children that are not the biological offspring of the household head and/or spouse; these could be stepchildren, adopted children, or grandchildren. These households may have high dependency ratios but it may not be the dependency ratio per se that is associated with youth growth and nutritional status; in other words, it might be household type and not household composition that matters. We address this concern by including a variety of measures of household type in the multivariate models that capture the alternative conditions under which households are formed.

In this sample of households, 63% of households were classified as nuclear family households, defined as consisting of a husband, wife, and child or children. Approximately 20% of households had household heads who were polygynous and 18% of households were female headed. Grandchildren were present in 11% of households, and the parents or parents in law of the household head and/ or spouse were present in 5% of households. Kin of the household head or spouse were present in 15% of households, and 4% of households had other individuals who were unrelated to the household head and/or spouse (note that percentages sum to more than 100 because some households fall into more than one household type). Correlation analysis demonstrated that households with more grandchildren had significantly higher dependency ratios, and households with more kin had lower dependency ratios ($P<0.01$). Compared to male-headed households, female-headed households had lower dependency ratios ($P < 0.01$). Overall, nonnuclear households had higher dependency ratios than nuclear households (97 vs. 85, $P < 0.01$).

These correlations suggest the possibility that household type and not the dependency ratio per se influence nutritional status. To test this explanation, we re-ran the regression models and assessed whether the size and significance of the coefficient for the household dependency ratio was diminished when indicators of the various household types were included in the models. Because some of the household types were represented by only a small number of households, the analyses were run using the following variables: nuclear vs. nonnuclear household, male headed vs. female headed, any grandchildren in the household, and any kin in the household.

Only BMI and MUAC were significantly associated with household type in the multivariable models that included a dummy for nuclear household, and in both models nuclear households were associated with significantly lower values, indicating poorer nutritional status. Controlling for age, gender, dependency ratio, household income, place, and household size, youth in nuclear households had an estimated MUAC of 21.7 cm compared with an estimated 22.1 cm among youth in non-nuclear households (partial $P = 0.01$). Similarly, youth in nuclear households had an estimated BMI of 17.8 compared with an estimated BMI of 18.0 among youth in non-nuclear households; this small difference was statistically signifi-cant (partial $P = 0.02$). No other nutritional outcomes were associated with household type, when defined as nuclear or non-nuclear. The coefficient for the dependency ratio remained significant in all models (except for height and HAZ, as above), and the size of the coefficient shifted by around 1–2% in the models when the household type variable was included.

Households with grandchildren, other kin, and that were female-headed showed some associations with the nutritional outcomes, but none altered the impact of the dependency ratio on nonheight related measures. There was no association between having grandchildren in a household and youth weight, height, WAZ, or HAZ. Youth living in households with grandchildren did however, independent of other covariates, have greater MUAC (about 0.9 cm greater, partial $P < 0.01$) than youth living in households without any grandchildren. Youth living in households with grandchildren also had an estimated BMI that was 0.33 greater than the BMI of youth living in households without grandchildren (partial $P = 0.04$). Inclusion of the dummy for grandchildren in the household reduced the size of the household dependency ratio coefficient by about 4% but in no case did dependency become nonsignificant (or even close).

Households that included kin of the household head and/or spouse also had youth with slightly better nutritional status relative to households with no kin present. This was true for MUAC (0.3 cm, partial $P = 0.01$), and BMI (0.4 BMI, partial $P < 0.01$). In each case, the dummy variable for "household with extended kin" was significant and positive, suggesting

those household types promote health, even after controlling for other variables. In each of these models, the coefficient for the household dependency ratio decreased by about 2% but remained significant. Youth living in female-headed households also appeared to be at a slight nutritional advantage. In the multivariable model with a dummy for "Household is female-headed," evidence of a nutritional advantage among youth in female-headed households was shown for weight (1.1 kg, partial $P = 0.02$), MUAC (0.7 cm, partial $P < 0.01$), WAZ (0.2 WAZ, partial $P = 0.03$) and HAZ (0.1 HAZ, partial $P = 0.04$). There was no association between female-headed household and youth BMI (partial $P = 0.24$). Despite these statistically significant effects, the coefficient for household dependency remained significant for all outcomes except HAZ and height (as shown above) and changed by about 5% with the inclusion of the variable for gender of household head.

DISCUSSION

This study was undertaken to examine the potential individual-level impacts of macro-demographic changes. More specifically, the analyses explored the implications of shifting household age structures on one component of youth human capital, nutritional status. The results suggest a consistent association between household structure and youth nutritional status, except for height. The findings on dependency ratio are strengthened by controlling for youth gender and age as well as household income, workload and place and by carrying out a series of tests of alternative hypotheses that focused on household type and not composition, per se. We also described broad differences between populations in indicators of nutritional wellbeing. Comparisons with the CDC 2000 growth data show unequivocally that youth in Ethiopia tend to be shorter and lighter than their US peers. Comparisons with other studies of African youth also tend to support the hypothesis that African youth have relatively poorer nutritional status than their US counterparts, and that this Ethiopian sample, especially the rural sample, tends to be shorter and lighter than their African peers from Cameroon, Kenya, Mali, and Nigeria (Brabin et al., 1997; Pawloski, 2002; Leenstra et al., 2005; Semproli and Gualdi-Russo, 2007; Ayoola et al., 2009; Dapi et al., 2009). This study makes several contributions to the existing literature on adolescent nutritional status including the inclusion of both males and females, sampling across diverse agroecological zones, inclusion of alternative measures of household dependency ratio in multivariable models, and a focus on household structure, which is linked to the massive ongoing shifts in the populations of many low-income countries where youth cohorts dominate. The central limitation of this work is the observational nature of the study and the inability to isolate dependency ratio as a cause of varying levels of weight, MUAC, and BMI. This is a problem that plagues observational research and may be particularly acute in this study as decisions about how many children to have and how much to invest may be part of rapidly shifting cultural models.

The results show a consistent negative association between living in a rural area and indicators of nutritional status, weight, and MUAC, which is important given that urban populations are increasing rapidly (Montgomery, 2008). Interestingly this effect persists when other household covariates are included in the models. It is also interesting that the semiurban sites, at least nutritionally, appear to more closely match the urban sites. What aspect of rural living that is not captured by the variables might lead to this persistent growth handicap? Others have suggested that this may be the result of socioeconomic differences but the effect persists even after controlling for household income. Another hypothesis is that seasonal variation in food quality and quantity account for at least some of the differences and one can imagine a model of seasonally slowed growth that disallows individuals from achieving the same levels of weight and adiposity (Ulijaszek and Strickland, 1993). This hypothesis assumes that growth, especially in soft tissue, is sensitive to seasonal shifts in food quality and quantity and disease load, and that any catch-up growth

is insufficient to completely ameliorate growth deficits. Over time then deficits may accumulate and produce the place-level differences described here. It may also be that rural households as a group have poorer access to clean water (or some other community-level resource not measured) that may increase the burden of disease and thus reduce growth, a classic life history tradeoff. If communities were constrained in their access to clean water then household level covariates would do little to attenuate this effect in the face of these large constraints. One way to test this hypothesis would be to collect community-level data on health resources. The place level findings imply that as Ethiopia follows the rest of the world and becomes more urbanized (Montgomery, 2008), youth may enjoy greater growth and nutritional status.

In an effort to examine the potential individual level impact of macro-demographic phenomena we tested for household composition effects, namely the age structure of the household. Leslie and Pawloski (2009) have also recently drawn attention to household composition, household type, and place of residence as potential determinants of nutritional status of youth. Specifically, they have shown that female adolescents in Mali living in households with servants and with relatively larger numbers of wives are at an "unequivocal" nutritional advantage. We tested for a wife-effect by examining whether youth in polygynous households were associated with greater nutritional status, but did not find an effect, although there were a very small number of such households. We also tried to examine whether household dependency ratio results were due to different household types. These analyses confirmed that household type is associated with some measures of youth nutritional status. In general, youth did better nutritionally if they lived in households with grandchildren, other kin, and that were female-headed. This might suggest that there is a benefit to extra helpers in the household. Alternatively, it may be that grandchildren and additional kin select into households that are able to support additional children and adults. This would suggest then that youth in these households would do even better nutritionally if they did not have these extra individuals in the household.

Youth in female-headed households were slightly but significantly taller and heavier and had larger MUAC than youth in male-headed households, even after controlling for a number of individual, household, and place variables. This result, while initially surprising because female-headed households are substantially poorer in this sample, is consistent with a large literature on the nutritional status of children living in female-headed households (Kennedy and Peters, 1992; Johnson and Rogers, 1993; Onyango et al., 1994; Pryer et al., 2004). This female-headed advantage is thought to occur because women may privilege children's health and well-being in spending decisions (Handa, 1996; Guyer, 1997). Consistent with this theory, a logistic regression model showed that in the JLFSY dataset, female-headed households were less likely to be food insecure, once the effects of income were controlled (results not shown).

Regarding dependency ratio, the results show that, controlling for a range of other covariates, dependency ratio predicts weight, MUAC, BMI, WAZ, and BMIZ but not height or HAZ. This makes sense, as height and HAZ are likely long-term measures of nutritional status. Household age structure is, on the other hand, likely to impact on nutritional status primarily through its impact on currently available household/familial resources and, therefore, should show more significant associations with measures that include weight. It is interesting, however, that the household dependency ratio is associated with nutritional outcomes even when household work and household income are statistically controlled for. This is interesting because the theory underlining the hypothesis suggests that the household dependency ratio should impact on youth nutritional status through household income and workloads. In other words, we might expect the household dependency ratio to lose its statistical significance in the regression models once household income and workloads are

included; this would be a classic case of mediation (Frazier et al., 2004). Subsequent analyses on these data did reveal some evidence for mediation: the coefficient for the household dependency ratio term in the statistical models generally decreased by about 10% when income was added into the models. Although this never rendered the dependency ratio variable insignificant it does suggests that some of the effect of the household dependency ratio on nutritional outcomes is due to the income stress in households with many dependents relative to workers. The same was not true for workloads, which was not an important predictor in most of the estimated models.

The fact that income and the household dependency ratio are both significant in some or all of the models above suggest the theory is incomplete. If the theory is correct and household dependency does pattern the availability of familial resources that impact on nutritional status then one or more of the following must be true: there is error in the measures of income or workloads, there are other familial resources that impact on nutrition that are unmeasured (like caregiving), or a third variable, for instance parental attitudes about investment, determines both household dependency and nutritional status. Parental attitudinal data on caregiving and visions of their children's futures and how these are associated with dependency ratio would be useful, but we lack these data. Also lacking was a measure of illness that is sensitive enough to explore dependency ratio effects, although illness and health seeking might be important pathways through which dependency ratios impact on nutritional status. Each of these is a plausible hypothesis, but we tend to favor the first explanation because income is notoriously difficult to measure, especially in communities where employment might be highly sporadic and informal. Measuring workloads and, by implication, energy expenditure is also notoriously difficult and it is likely that our measures capture workloads in only a very crude fashion. Other studies have also reported conflicting results on the relationship between measures of workloads and female adolescents' nutritional status (Garnier and Benefice, 2001; Leslie and Pawloski, 2009).

One interpretation of the results having to do with the dependency ratios, and the one that is favored here, is that as household dependency ratios decline, youth nutritional status will improve because more familial resources are available for each household member. This is effectively the argument of the demographic window of opportunity and similar to arguments from the new home economics and life history theory about quality–quantity tradeoffs—all else equal, as family size declines there is more to invest in each individual. This interpretation should be made cautiously given the cross-sectional nature of these data but an implication of the relationship between the dependency ratio and youth nutritional status is that as long as fertility rates continue to decline, youth nutritional status will show small but consistent improvements even if household income remains stagnant. In other words, improvements in this one element of human capital should be expected. To the extent that nutritional status is linked to fertility, educational, and employment outcomes, changes in household composition could have far reaching consequences for individual human capital, and for population health, which is summed across all individuals. On the other hand, because of population momentum, populations in many parts of the world, including Ethiopia, will continue to grow. This generates a paradox: within households, individuals will have fewer competitors for resources than prior generations while outside of the household they will have more; this is a point also made by Lam and colleagues (2005). Youth will be entering into a more constrained labor market but will enter into that market with higher levels of human capital than previous cohorts. This mismatch between household and community opportunities has the potential to generate psychosocial tension and perhaps frustration.

This study sought to make several contributions to the existing data on youth nutritional status. First we sought to add a new sample to the small number of studies on youth nutritional status in developing countries that included large numbers of males and females living in diverse agroecological zones. In doing so the aim was to increase the knowledge base on the nutritional status of the world's adolescents. Second, we sought to explore the implications of shifting macro-demographic structures for individual level human capital. We hypothesized that shifts in the dependency ratio would, all else equal, lead to a greater availability of household resources for young people, and these resources would be transmitted into greater health and wellbeing, including nutritional status. The results suggest that the household dependency ratio is indeed associated with youth nutritional status. This is but one possible consequence of shifting age structures and the global decline in fertility rates. Future research should explore other biosocial implications of young people growing up in novel, small family households.

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TABLE 1

Females weight, height, mid-upper arm circumference (MUAC), and body mass index (BMI)

Age in years	Weight		Height		BMI		MUAC	
	KG	SD	CM	SD	MEAN	SD	CM	SD
Females								
13–13.9 y (*n* = 196)	37.17[**]	6.48	148.72	7.54	16.73[**]	2.06	20.31[**]	2.26
14–14.9 y (*n* = 211)	42.22[**]	6.99	153.59	6.77	17.86[**]	2.48	21.81[**]	2.42
15–15.9 y (*n* = 232)	46.83[*]	6.83	155.85[**]	6.14	19.25[**]	2.36	23.27[**]	2.84
16–16.9 y (*n* = 175)	48.29	6.03	156.70[**]	6.50	19.71[**]	2.49	23.66[**]	2.56
17–17.9 y (*n* = 120)	51.08	6.94	158.07[**]	6.26	20.47[**]	2.81	24.81[**]	2.85
Males								
13–13.9 y (*n* = 228)	34.63	5.98	147.23	9.35	15.97	2.49	18.95	1.84
14–14.9 y (*n* = 233)	39.86	7.29	154.83	10.29	16.52	1.905	20.32	2.28
15–15.9 y (*n* = 215)	45.36	8.58	160.97	10.08	17.38	2.253	21.67	3.42
16–16.9 y (*n* = 181)	49.11	7.51	165.31	8.30	17.91	2.024	22.74	3.22
17–17.9 y (*n* = 142)	51.28	7.48	167.08	8.69	18.32	2.234	23.37	2.58

Table shows mean and standard deviation.

[*] Comparison between male and female is significant at *P* < 0.05.

[**] Comparison between male and female is significant at *P* < 0.01.

TABLE 2

Regression model predicting weight (kg) of respondents in JLFSY (Model R^2 = 38%)

	Beta	SE	*P*	Bivariate model R^2
Intercept	−9.9845	2.0196	<0.001	
Age, yrs	3.7307	0.1270	<0.001	35%
Sex, 1 = male	0.2841	0.6875	0.6795	<1%
Urban		Reference		
Semi	0.1099	0.4050	0.7862	<1%
Rural	−1.2375	0.4569	0.0068	3%
Household size	−0.0649	0.0530	0.2206	1%
Household dependency ratio	−0.0062	0.0024	0.008	9%
Household income, birr/wk	0.0020	0.0009	0.0223	1%
Workload	0.0193	0.0148	0.1934	<1%
Sex x Workload	−0.0564	0.0212	0.0078	2%

Beta coefficients show the change in the outcome variable given a 1-unit change in the independent variable, adjusting for all other covariates.

TABLE 3

Regression model predicting MUAC (cm) among respondents in JLFSY (Model R^2 = 35%)

	Beta	SE	*P*	Bivariate model R^2
Intercept	8.4089	0.7183	<0.001	
Age, yrs	1.0043	0.0452	<0.001	23%
Sex, 1 = male	−0.8497	0.2447	0.0005	5%
Urban		Reference		
Semi	−0.5726	0.1444	<.0001	<1%
Rural	− 1.3682	0.1627	<.0001	6%
Household size	−0.0206	0.0188	0.2737	<2%
Household dependency ratio	−0.0025	0.0008	0.0025	8%
Household income, birr/wk	0.0005	0.0003	0.0898	1%
Workload	0.0077	0.0053	0.1447	<1%
Sex × Workload	−0.0168	0.0075	0.0261	2%

Beta coefficients show the change in the outcome variable given a 1-unit change in the independent variable, adjusting for all other covariates.

TABLE 4

Regression modeling predicting BMI among respondents in JLFSY (Model R^2 = 27%)

	Beta	SE	*P*	Bivariate model R^2
Intercept	8.2378	0.6416	<0.001	
Age, yrs	0.7109	0.0403	<0.001	15%
Sex, 1 = male	−1.3197	0.2188	<0.001	9%
Urban		Reference		
Semi	0.1151	0.1288	0.3716	<1%
Rural	−0.4464	0.1452	0.0021	2%
Household size	0.0061	0.0168	0.7182	<1%
Household dependency ratio	−0.0024	0.0007	0.0011	5%
Household income, birr/wk	0.0001	0.0003	0.7027	<1%
Workload	0.0055	0.0047	0.2461	<1%
Sex x Workload	−0.0081	0.0067	0.2288	<1%

Beta coefficients show the change in the outcome variable given a 1-unit change in the independent variable, adjusting for all other covariates.

TABLE 5

Regression model predicting height (cm) among respondents in JLFSY (Model R^2 = 31%)

	Beta	SE	*P*	Bivariate model R^2
Intercept	100.2303	2.4155	<0.0001	
Age, yrs	3.7117	0.1518	<0.0001	25%
Sex, 1 = male	5.5689	0.8246	<0.0001	4%
Urban		Reference		
Semi	−0.3172	0.4853	0.5134	<1%
Rural	−0.3229	0.5466	0.5548	<1%
Household size	−0.1526	0.0634	0.0161	<1%
Household dependency ratio	−0.0015	0.0028	0.5966	4%
Household income, birr/wk	0.0033	0.0011	0.0018	<1%
Workload	0.0099	0.0178	0.5796	2%
Sex × Workload	−0.0579	0.0254	0.0226	4%

Beta coefficients show the change in the outcome variable given a 1-unit change in the independent variable, adjusting for all other covariates.