

Prevalence of thinness in adolescent girls in low and middle-income countries and associations with wealth, food security and inequality

## **Abstract**

### Purpose

Adequate nutrition during adolescence is important for optimal physical and cognitive development and for pregnancy either during adolescence or later life. Thinness amongst adolescent girls in low and middle income countries (LMIC) has been little studied.

### Methods

We used BMI data from 40 countries from the Global School Health Survey to estimate the prevalence of moderate and severe thinness in 12-18 year olds using the WHO 2007 growth reference. Self-report data on going to bed hungry were used as a proxy for household food insecurity. We used multi-level models to assess whether national wealth (gross domestic product, GDP), income inequality (Gini index), national gender inequality (Gender Inequality Index (GII)) and food security (Global Food Security Index (GFSI)) were associated with undernutrition.

### Results

Prevalence rates of moderate and severe thinness across 61,603 girls from 40 countries were 6.30% (95% CI: 5.71, 6.95) and 1.34% (1.12, 1.59) respectively, with higher rates in Asia. Combined moderate/severe thinness was more common amongst early (12-14 years) than later adolescents (15-18 years). Going to bed hungry sometimes was associated with increased risk of moderate/severe thinness (OR: 1.102; 95% CI 1.007, 1.206). A significant inverse relationship was found between thinness and GDP (OR: 0.94; 95% CI: 0.88, 0.99) and GFSI (OR: 0.96; 95% CI: 0.93, 0.99) but not Gini or GII

### Conclusion

Thinness remains prevalent in adolescent schoolgirls in LMIC, and poses a significant threat to their health and that of the next generation. Further research is needed to assess potential interventions for this group.

**Keywords** Adolescent, nutrition, thinness, food security, female, global

## **Implications and contribution**

Our data show that undernutrition remains a global threat to the health of adolescents and the next generation; the prevalence of moderate/severe thinness averaged 7.6% amongst adolescent girls across low and middle income countries. These are the first systematic data on adolescent thinness to guide national and international nutrition strategies.

## Introduction

Malnutrition, including undernutrition, stunting and thinness, is a major cause of mortality and morbidity amongst children globally,(1) and has important consequences for healthy development and the economic productivity of individuals and societies.(2) Maternal undernutrition is also a major contributor to childhood mortality as well as maternal mortality and a range of other poor outcomes.(2) Yet undernutrition and thinness amongst adolescents, who are both children emerging into adulthood as well as frequently mothers themselves, has been little studied. This is despite emerging international recognition of the importance of adolescence for global health, and that improving the health of adolescent girls may impact not only on the individual but also on future generations.

Globally, 1.2 billion young people are aged 10-19 years, 90% of whom live in low and middle income countries (LMIC).(3) Adolescence is a period of rapid maturation in all organ systems, with higher nutritional demands which place adolescents at greater risk of malnutrition. As in childhood, adequate nutrition during rapid brain development in adolescence is important for achieving optimal cognitive outcomes and to place young people on a trajectory towards being productive adults.(4) Further, adolescence has been shown to be an important time for catch up growth, when previous effects of poor childhood nutrition may be reversed or ameliorated.(5) Child-bearing during adolescence places an additional nutritional burden on the mother, and may explain some of the additional risk(6) that pregnancy in adolescence poses to the 16 million teenagers who give birth annually(7) and to their offspring.

Whereas the global prevalence and patterns of undernutrition amongst children is well documented,(1) and routinely included in population-health benchmarks provided by various United Nations (UN) agencies, there has been no systematic study of the prevalence of thinness amongst adolescents. Younger adolescents (i.e. < 15 years), are not included in routine data collection systems, such as the demographic health survey (DHS).(3)

Available data for LMIC come largely from within-country analyses, with the most comprehensive data from a study of 10 countries.(2) Country-level studies suggest that the prevalence of undernutrition amongst adolescent girls varies widely between LMICs with much of the data originating from Africa (8, 9), South East Asia (10-12) and India(13, 14) with fewer studies from South America.(15) There is notable variability in age ranges, definitions of underweight and recruitment and making international comparison challenging. Data from Indian studies suggest that between 39.4% to 42.6% of adolescent girls are underweight,(13)(14) with much lower prevalences reported by studies from Turkey

(5.0% of 14-18 year old schoolgirls were underweight)(16) and Brazil where only 2.5% of 12-18 year old girls were underweight.(15)

We aimed to estimate the prevalence of thinness amongst adolescent girls in LMIC globally, using data from the WHO Global School Health Survey (GSHS) and from established WHO definitions of thinness. The WHO defines thinness as BMI-for-age Z-score  $<-2$  SD and severe thinness as BMI-for-age Z-score  $<-3$  SD.(17, 18) Further, given evidence that childhood malnutrition is influenced by national wealth and food availability(19) and by gender inequality,(20) we hypothesised that a country's levels of thinness amongst adolescent girls would be influenced by that country's macroeconomic context such as national wealth and the distribution of income as well as by gender equality and the security of a country's food supply. We therefore additionally examined whether indicators of national wealth, income or gender inequality, hunger and national food security were associated with the prevalence of thinness. Understanding the patterns of adolescent thinness across LMIC will provide valuable information for policy makers about where best to target nutritional interventions in this age group.

## Methods

Our cross-sectional study examined associations between individual level data (body mass index (BMI) and demographic data) collected in a clustered sample design from 40 countries and aggregated country-level data (indices of food security, gender inequity, income and income inequality).

Data were obtained from the Global School Health Survey (GSHS), an international survey of young people aged 11 to 17/18 years in LMIC sponsored by the World Health Organisation (WHO); see details published previously.<sup>(21)</sup> The survey provides self-reported data from young people in schools relating to a range of health outcomes together with measured height and weight. Publicly available data deposited by the WHO were accessed on 11 November 2013. Data were available for 66 countries collected between 2003 and 2011 (see Appendix). Participants reported being aged 11 years or younger; 12, 13 14 or 15 years or 16 years or older. We excluded those aged 11 years or younger as these may have included small numbers of children 10 years. The majority of the included countries were originally classified as LMIC when the GSHS began, with the exclusion of the United Arab Emirates which has been excluded from these analyses.

In each country, survey administrators were given a day training in aspects of delivery of the survey including anthropometry. All participating schools were given a portable height / length training board, weighing scales and data entry sheet.<sup>(22)</sup> Young people were measured by survey staff without shoes on, with the measurement given to students on a slip of paper who then entered their height and weight onto the GSHS answer sheet during survey administration.

We excluded biologically implausible values using standardised rules. BMI Z-scores were calculated according to the WHO 2007 growth references.<sup>(17)</sup> Individuals were then categorised as having moderate thinness if BMI Z-score was between -2.01 to -3.00, or severe thinness if Z-score was <-3<sup>(18)</sup>. We report prevalence rates of combined moderate and severe thinness and of severe thinness alone.

Of the 66 countries with available survey data, 61 provided BMI data on a total of 144,057 participants (82,838 (57.5%) girls). Many countries had high rates of missing BMI data, due to either the participant not being measured in certain schools or individual participants not entering their measurement data. To minimise bias, for these analyses we included only countries where >67% of the cohort had height and weight data; 40 countries met this

requirement (see Appendix for details of included countries). The sample therefore comprised 61,603 girls across 40 countries aged 12 years or older (74.4% of those with BMI data). Year of data collection varied from 2003 to 2011, with most collected between 2007 and 2010 (see Appendix). Where a country repeated data collection during this time, we used the most recent year of data.

Young people's reports of going to bed hungry were included as a marker of family level household food security, a proxy for household deprivation. Young people were asked "During the past 30 days, did you go hungry because there was not enough food in your home?", with responses being never, rarely, sometimes, most of the time or always. We collapsed the responses into three categories; never/rarely, sometimes or most of the time/always. The GSHS provided no measures of nutritional intake or physical activity collected across all countries.

#### Country-level data

National wealth was assessed using the Gross domestic product (GDP) per capita based on purchasing power parity (PPP) in current international dollars obtained from the World Bank(23) for the same year of the GSHS survey in each country.

National income inequality was assessed using the Gini index, which measures the extent to which the distribution of income among individuals or households within an economy deviates from a perfectly equal distribution. Data were obtained for the closest year to country data collection from the World Bank.(24)

National food security was assessed using the Global Food Security Index (GFSI) for 2012-13, an index compiled by the Economic Intelligence Unit from 28 unique indicators across the core issues of affordability and availability of food, as well as food quality and safety (including diet diversification, micronutrient availability, protein quality, nutritional standards and food safety) and available for a set of 109 countries.(25)

Data on gender equality for countries were obtained from the Gender Inequality Index (GII), developed by the United Nations Development Programme (data from 2005-2010) from data including the maternal mortality ratio, adolescent fertility rates, educational attainment statistics and women's parliamentary representation and labour market participation in each country.(26) National data by country are shown in the Appendix.

#### Analyses:

Analyses were undertaken in Stata version 13 (StataCorp, College Station, TX) with all analyses taking account of design effects (population weights; clustering at the school primary sampling unit and classroom stratum level). Descriptive statistics were run for the whole sample and by country on the prevalence of moderate/severe and severe thinness. Analyses of the associations of thinness with individual factors (age and going to bed hungry) and national level indices (GDP, Gini, GII and GFSI) were undertaken using multilevel models. All models were adjusted for age, year of BMI data collection and year of collection of national index data. Models for national indices were then repeated after further adjusting for going to bed hungry. Models were tested for cross-level interactions between national indices and individual demographic factors. Models for Gini were also adjusted for whether the Gini was related to income or expenditure, net or gross income or household or individual income calculations. For macroeconomic variables significantly associated with thinness, we calculated the proportional reduction in country-level variance from the from the model adjusted for individual-level factors.(24)

Ethics: No ethical review was required for these secondary analyses of publicly available data.



## Results

Complete data on BMI were available on 61,603 girls from 40 countries. Overall prevalence (across all countries) for severe, moderate and combined moderate/severe thinness were 1.34% (95% CI: 1.12, 1.59), 6.30% (5.71, 6.95) and 7.63% (6.90, 8.43) respectively. Year of collection of GSHS data was not associated with prevalence of moderate or severe thinness.

The prevalence of moderate and severe thinness (separately) by country are shown in Figure 1 for girls of all ages, together with total prevalence across the sample and the median of country-level prevalences. Prevalence of moderate underweight varied between 19.3% in Sri Lanka and 0% in Tonga and Niue. An unadjusted multi-level model confirmed significant variation between countries in the prevalence of combined moderate / severe thinness. Countries with prevalence of moderate/severe thinness significantly lower than the mean included Tonga, Chile, Cook Islands, Guatemala, Peru, Uruguay, Argentina, Jamaica, Uganda, the UAE, Libya and Egypt. Those with prevalence significantly higher than the mean included China, Seychelles, Thailand, Algeria, Syria, Djibouti, Philippines, Suriname, Morocco, Guyana, Fiji, Myanmar, Pakistan, India, Indonesia, Yemen and Sri Lanka.

Prevalence of moderate/severe thinness by age-group (12-14 years and 15 years or older) is shown in Figure 2. In the sample across all countries, 1.40% (1.15, 1.71) of 12-14 year olds (early adolescents) had severe thinness, which was not significantly different to the 1.21% (0.89, 1.66) of 15 -18 year olds (late adolescents) with severe thinness. However, this proportion of adolescents with severe thinness was 7 times the expected prevalence from use of the <3 SD cut point (using the WHO growth charts as comparison). In contrast, moderate/severe thinness was less common amongst late (6.82% (5.96, 7.80)) compared with early (8.10% (7.27, 9.01)) adolescents (unadjusted multi-level model: odds ratio for older age group 0.88 (95% CI: 0.82, 0.96)  $p=0.002$ ). This was approximately 3 times expected prevalence if using the <-2 SD cut point on the WHO growth charts as comparison.

Data on going to bed hungry and BMI were available on 61,138 girls (99% of sample with BMI data). Across the whole sample, 24.2% (21.4, 27.2) of those with moderate/severe thinness and 21.7% (20.5, 22.9) of those with normal/high BMI went to bed hungry sometimes, and 5.6% (4.2, 7.6) of those with thinness and 5.9% (5.5, 6.4) with normal/high BMI went to bed hungry most of the time or always, with the remainder reporting never/rarely going to bed hungry. . In multi-level models adjusting for age and year of data collection, going to bed hungry sometimes or always was associated with increased risk of

moderate/severe thinness at low significance. Going to bed hungry was not associated with severe thinness (see Table 1).

The country-level variance (ICC) for moderate/severe thinness adjusted for individual level factors (going to bed hungry and age) was 24.0% (15.9, 34.6).

#### Thinness and national indicators

Associations between thinness and national indicators are shown in Table 1. In multilevel models adjusted for age and year of GSHS data collection, odds of moderate or severe thinness were inversely associated with GFSI but not with GII or Gini, with the association with GDP narrowly missing significance ( $p=0.06$ ). Severe thinness was not significantly associated with any national indices. When further adjusted for individual report of going to bed hungry, there was a small inverse relationship at low significance between risk of moderate or severe thinness and GDP (OR: 0.94; 95% CI: 0.88, 0.99) and also an inverse significant relationship with GFSI (OR: 0.96; 95% CI: 0.93, 0.99). Adjustment for GDP and going to bed hungry reduced country-level variance to 20.3% (13.1, 30.2), a reduction of 15.4% compared with the model adjusted for individual-level factors. Adjustment for GFSI and going to bed hungry reduced country-level variance to 18.9% (11.4, 29.7), a reduction of 21.3% compared with the model adjusted for individual-level factors.

We found no significant cross-level interaction between going to bed hungry and GDP, but there was a significant positive interaction between going to bed hungry and GFSI ( $p=0.04$ ).

## Discussion

We present the first data from 40 LMICs on the prevalence of thinness in a large sample of adolescent girls entering child-bearing age. Thinness was more common amongst younger rather than older adolescents and amongst those with family food insecurity. Approximately 1 in 12 (7.6%) girls had moderate or severe thinness, ranging from 0% in Tonga to nearly 20% in Sri Lanka. The highest prevalence were found in Asian countries, with Sri-Lanka, Indonesia, India, Myanmar and Pakistan having 10% or more of their adolescent girls being moderately or severely thin. Approximately 24% of the variance in thinness in the sample was at country level when adjusted for individual level factors (age and family food security), showing that country-level socioeconomic and cultural factors play a major role in determining the prevalence of thinness in adolescent girls. We found that poorer countries and those with greater food insecurity had higher prevalence of thinness amongst adolescent girls when individual-level household food security was taken into account. However the relationship with national wealth (GDP) was at low significance and we found that adding national food insecurity (GFSI) to models decreased country-level variance by 21%. These suggest that issues related to national food security play a major role in determining the prevalence of adolescent thinness in a country, with overall national wealth less important. Further, going to bed hungry was more strongly associated with risk of thinness in countries with greater food insecurity, again suggesting national food security may be a key determinant of adolescent thinness. However, we did not find that country-level prevalence of thinness was associated with national income inequality or with gender inequality.

Our finding that countries in Central and South America had a lower prevalence of thinness compared to countries in South East Asia and the Indian subcontinent is consistent with previous country-level studies,(2, 27) and we note that the former had the highest GFSI amongst the countries (see Appendix). Similarly, our finding that prevalence of thinness decreased with age in LMIC is consistent with previous work.(27) Our prevalence findings for Africa are similar to that of previous studies.(28) Our finding that thinness is associated with food insecurity is consistent with previous studies of younger children.(29)

The prevalence of thinness should raise concern, given that thinness in adolescent girls also has important implications for the health of the next generation. A new focus is needed by LMIC on measuring and reducing adolescent thinness, to improve cognitive and health

outcomes for young women and to reduce the associated risks of higher maternal mortality,(30) infant mortality,(31) prematurity and foetal growth restriction.(2)

Whilst our findings are cross-sectional and do not prove causality, they imply a role for macroeconomic factors in the genesis of adolescent thinness and suggest that efforts to promote national food security and economic development may reduce adolescent thinness. However, given our finding that personal food insufficiency (i.e. going to bed hungry) was also associated with adolescent thinness, direct health investments to improve diet, morbidity and thinness status are also needed.

Given the relatively weak associations between macroeconomic climate and thinness, this may imply that these short term economic factors are not enough to directly impact on thinness in this population. The WHO expert committee on the use and interpretation of anthropometry suggested using BMI surveys to assess adolescent thinness every 5 years during times of socioeconomic change or whilst specific programmes are in place to improve thinness in this population, otherwise surveys should be used every 10 years. They did acknowledge that adolescent thinness may be a useful indicator of social and economic change or improvement. Importantly, stunting can occur due to undernutrition over many years and therefore may not be captured in the fluctuations in GDP in the shorter term.

A recent review of interventions for child and maternal thinness(32) showed a paucity of evidence for effective interventions for adolescents, with most evidence-based interventions concentrating on maternal and infant nutrition. The negative impact of preconception anaemia in young women on rates of low birth weight (LBW) and foetal birth restriction(33) suggests supplementation of young women may improve neonatal outcomes. Efforts to reduce adolescent pregnancies and space out subsequent pregnancies may indirectly positively impact on adolescent nutritional state. Providing access to reproductive and family planning services for adolescents may reduce the risk of unwanted pregnancies and raise the age of first pregnancy, which are likely to improve young women's nutritional status. Successful interventions to improve maternal health and nutrition include micronutrient or iron or folic acid supplementation which have demonstrated small reductions in LBW infants rates and reduction in anaemia in mothers.(34) School based interventions including school feeding programmes for younger children have shown better school attendance and improved nutrition.(35) Such programmes could provide an avenue for education and monitoring of nutritional status amongst adolescents and hence lead to

reduced levels of thinness. All such interventions should examine for health outcomes other than nutritional status, such as cardiovascular risk and cognition.

### *Strengths and limitations*

We used data from a World Health Organisation sponsored survey using standardised data collection methods across 40 LMIC. Sampling strategies produced generalizable samples for each country. Data were analysed using multilevel regression techniques accounting for clustering within schools, regions and countries. Data on country level predictors were obtained from authoritative sources.

Our data had several limitations. Our findings are likely to under-estimate the true prevalence of thinness amongst adolescents, especially those countries with relatively higher levels of gender inequality, as some of the poorest girls most likely to be thin will not be in school. Approximately 22% of adolescent girls in LMIC are not enrolled in lower secondary school in 2007, ranging from 1.8% in Dominica to 73.14% in Djibouti.(36) This suggests that our data may particularly under-estimate thinness in African countries where school participation is lowest, although school drop out after enrolment is also high in South Asian countries. Young women who dropped out of school due to earlier pregnancies(37) which can be detrimental to the nutritional status and outcomes for both the mother and offspring, may contribute to our under-estimation of thinness.

We did not include data from 21 of the 61 countries in the GSHS series due to high (>33%) missing BMI data at country level. Missing BMI data in these countries ranged from 34 to 97%. However, the overall prevalence of moderate and severe thinness in these countries was 7.2%, little different to that across included countries ( $p=0.10$ ). Non-included countries had a higher mean GDP (\$20,800 per annum) than included countries (\$12,900) but highly similar other national indicators.

Our use of an international growth standard does not take account of possible ethnic differences in BMI distributions, and may over- or under-estimate undernutrition in some countries. Some of the global variation in thinness shown here could be attributed to ethnic or genetic variation in body composition. Studies comparing overweight and obese individuals from different ethnic groups suggest ethnic differences in body fat percentage may lead to misinterpretations of BMI with regard to underlying adiposity(38) Indeed, in our study, the majority of inter-country variation was not explained by GDP or GFSI, and may

relate to other national, ethnic or regional factors. However, there is still little evidence or international consensus to support the development of ethnic-specific growth references for children and adolescents.(39)

We defined thinness using age and sex-based norms, which are open to bias from misreporting of age. To minimize misclassification bias from age, we grouped age into two categories, younger and older adolescents.

The GSHS included no data on puberty, which usually acts to increase BMI in girls through increased fat mass deposition. The WHO growth reference is recommended by the WHO for international comparisons but does not consider pubertal timing. It is possible that national and ethnic differences in the timing of puberty and the pubertal growth spurt influenced the degree of thinness identified here between countries. The WHO growth reference relates to the average pubertal growth trajectory across the reference sample, which was based upon four separate samples of adolescents surveyed in the United States between 1963 and 1974.(17) Probably the prevalence of thinness was under-estimated in countries with mean age of puberty earlier than that of the growth reference, and over-estimated in those with later pubertal timing. Given that mean age of menarche approximates 12-14 years across most countries included in this study,(40) pubertal timing issues are likely to be an issue in only the early adolescent group (12-14 years). We found that the differences between countries reported here were largely consistent across both 12-14 and 15-18 year olds (see Figure 2), suggesting pubertal timing is unlikely to be a major source of bias here.

Lastly, we were unable to examine potential other causes of thinness. Whilst in some countries the GSHS included questions on diet and physical activity, these were not collected sufficiently consistently to examine as risk factors. Our dataset provided no information on the frequency of infectious, gastrointestinal disease or HIV status or pregnancy. We were unable to estimate the impact of HIV status on risk of thinness in adolescents in this study.

### *Conclusions*

Thinness is common in adolescent school girls entering reproductive years in LMIC, and poses a significant threat to their health and that of the next generation. National food security appears to have a major role in determining the prevalence of thinness in adolescent girls, and policy efforts to improve food security are likely to reduce thinness amongst future mothers and improve the health of the current and future generations.

Further work is needed to accurately estimate the burden of thinness in LMIC adolescent populations including the many girls not in school, and to better understand the causes and correlates of adolescent thinness in order to target interventions more effectively.

## **Author contributions**

Russell Viner had the idea for the study, undertook the analyses and contributed to the writing of the paper. Toby Candler led the writing of the paper. Silvia Costa prepared the data and contributed to writing of the paper. Michelle Heys and Anthony Costello contributed to the analysis plan and writing of the paper.



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Global Food Security Index (GFSI)	0.96	0.03	0.96	0.10	0.96	0.02	0.96	0.09
<i>46,318 observations from 23 countries</i>	(0.93, 0.99)		(0.92, 1.01)		(0.93, 0.99)		(0.92, 1.01)	

All models adjusted for year of data collection and age

Models for Gini were also adjusted for source of data (i.e. whether the Gini was related to income or expenditure, net or gross income or household or individual income calculations).(24)

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