

**Title:** The double burden of malnutrition among adolescents: analysis of data from the Global School-Based Student Health and Health Behaviour in School-Aged Children Surveys in 57 low-income and middle-income countries

**Running title:** Malnutrition among adolescents in LMICs

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## Abstract

**Background:** Adults and young children in countries experiencing the nutrition transition are known to be affected **simultaneously** by undernutrition and overnutrition. Adolescence is a critical period for growth and development. Yet, it is unknown to what extent this double burden **of malnutrition** affects adolescents in low- and middle-income countries (LMICs) and **the macro-level contextual factors associated with the double burden of malnutrition**.

**Objective:** To quantify the magnitude of the double burden of malnutrition among adolescents and examine **the** potential sources of heterogeneity in **prevalence** estimates across LMICs.

**Design:** We used individual-participant data from the Global School-Based Student Health Survey and Health Behaviour in School-Aged Children surveys done in 57 LMICs between 2003-2013, comprising 129,276 adolescents aged 12-15 years. Pooled estimates of stunting, thinness, stunting and/or thinness, overweight or obesity, and **concurrent** stunting and overweight or obesity were calculated overall, by regions, and stratified by sex, with random-effects meta-analysis. Guided by the **United Nations Children's Fund** (UNICEF) conceptual framework for child malnutrition, we used ecological linear regression models to examine the **association between macro-level contextual factors** [internal conflict, lack of democracy, **gross domestic product** (GDP), food insecurity, urbanisation and survey year] **and stunting, thinness and overweight and obesity prevalence, respectively**.

**Results:** Stunting prevalence was 10.2% (95% CI: 8.3, 12.2) and thinness prevalence was 5.5% (95% CI: 4.3, 6.9). **Overweight or obesity prevalence** was 21.4% (95% CI: 18.6, 24.2). **Between 38.4%-58.7% of the variance in adolescent malnutrition was explained by macro-level contextual factors**. The prevalence of concurrent stunting and overweight or obesity was 2.0% (1.7, 2.5).

**Conclusion:** The double burden of malnutrition among adolescents in LMICs is common. **Context-sensitive implementation and scale-up of interventions and policies for the double burden of malnutrition are needed** to achieve the sustainable development goal to end malnutrition in all its forms by 2030.

Keywords: adolescent; malnutrition; stunting; thinness; obese; double burden

#### Abbreviations used:

BMI, body mass index; CI, confidence intervals; GDP, gross domestic product; GSHS, Global School-Based Student Health Surveys; HSBC, Health Behaviour in School-Aged Children, LMICs, low- and middle-income countries, WHO, World Health Organisation; UNICEF, United Nations Children's Fund

## Introduction

Low- and middle-income countries (LMICs) formerly confronted with a high prevalence of undernutrition (stunting or thinness) (1) now must face overnutrition (overweight or obesity) as an additional burden. This is now referred as the “double burden of malnutrition”. Typically described in adults, now is affecting children (1, 2)— its magnitude among adolescents across LMICs remains poorly defined.

Despite 90% of adolescents living in LMICs, the global health community has largely neglected the health needs of this population (3). Adolescence is a period of rapid growth, with higher nutritional demands placing adolescents at greater risk of malnutrition. The nutritional status of adolescent girls is particularly important as adolescent fertility still accounts for 11% of all births globally, with 95% of these births occurring in LMICs (4). Stunting begins in utero and manifests itself across infancy and affects brain and muscle growth (1). Among adolescents, stunting is associated with impaired cognitive

development and school achievement, reduced economic productivity, (5) and poor reproductive health outcomes in females (6). Childhood stunting has also been reported to co-exist with overweight or obesity (7, 8). **The consequences of concurrent stunting and obesity in adolescents is likely to compound health issues in adolescence and later in adulthood, particularly for females given the heightened obstetric risk.** Thinness in adolescence is associated with delayed maturation, poor muscle strength leading to constraints in capacity for physical work, and reduced bone density later in life (9). Obesity in adolescence has been associated with an increased risk of early onset of adult chronic diseases (type 2 diabetes, hypertension) and mortality in adult life (10, 11).

Quantifying the double burden of malnutrition among adolescents and **examining the macro-level contextual factors shaping the distribution of the double burden across LMICs is important for policy makers to support actions to achieve the sustainable development goal of ending malnutrition in all its forms by 2030.** We estimate the burden of stunting, thinness, stunting and/or thinness, overweight or obesity, and **concurrent** stunting and overweight or obesity in adolescents aged 12-15 years in LMICs, using data from 57 nationwide school-based surveys during the years 2003-2013. We also investigated potential sources of heterogeneity in the estimates across countries.

## **Methods**

## 76    *Design*

77    We used the most recent Global School-Based Student Health Surveys (GSHS) and  
78    Health Behaviour in School-Aged Children (HSBC) surveys, with data available on  
79    height and weight. The GSHS is a World Health Organisation (WHO) initiative, designed  
80    to assess health behaviours of adolescents through cross-sectional school-based surveys,  
81    across several countries using similar standardised procedures (12). The HSBC study are  
82    WHO sponsored cross-sectional school-based surveys that uses similar standardised  
83    procedures to the GSHS to examine the physical and mental health of adolescents in the  
84    WHO European Region and North America (13).

## 85 86    *Anthropometry*

87    Trained survey staff weighed and measured the height of each student. Body mass index  
88    [BMI (weight in kilograms divided by height in meters squared)] was calculated from  
89    height and weight. Stunting was defined as height-for age < 2 standard deviations below  
90    the WHO Child Growth Reference median. Thinness was defined as BMI-for-age < 2  
91    standard deviations below the WHO Growth Reference median. Overweight was defined  
92    as BMI-for-age > 1 standard deviation above the WHO Growth Reference median) and  
93    obesity was defined as >2 standard deviations above the WHO Growth Reference  
94    median.

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## 99    *Statistical Analysis*

100    In view of the complex design of the surveys, we used sampling weights, and accounted

for stratification and clustering in the sample design to estimate the proportion and 95% confidence intervals (CI) for stunting, thinness, stunting and/or thinness, overweight or obesity, and concurrent stunting and overweight or obesity. Meta-analysis was done to synthesise the prevalence estimates overall and for WHO regions. Variances of the raw proportions were stabilised with a double arcsine transformation and then pooled based on a random-effects model. We calculated the pooled prevalence estimates and the 95% CIs. To evaluate the extent of heterogeneity of prevalence estimates between the LMICs, we used heterogeneity tests with the  $I^2$  statistic.

Guided by the **United Nations Children's Fund** (UNICEF) conceptual framework for child malnutrition (1), we examined **macro-level contextual factors** that **might** explain heterogeneity **in prevalence estimates for stunting, thinness and overweight or obesity**. **We first examined Pearson's** correlations between **macro-level contextual factors** (**including** recent internal conflict, lack of democracy, GDP per capita, food insecurity, % living in urban areas, and year of survey) and the overall prevalence of **stunting, thinness and overweight or obesity, respectively**. Significant **macro-level contextual factors** ( $p < 0.05$ ) were then entered into ecological multiple linear regression models. **Supplemental Table 1** provides a description of the **macro-level contextual factors**. For the outcomes thinness and overweight or obesity, **macro-level contextual factors** were extracted to correspond to the country's survey year and the 5 years prior (where available). The mean value was then calculated and used in correlation and regression

122 analyses. Because the causes of adolescent stunting occur much earlier in the life-course,  
123 we extracted **macro-level contextual factor data** to correspond to the mean age of the  
124 population at birth to 2 years old. The mean value was then calculated and used in  
125 correlation and regression analyses.

126

127 All statistical analyses were done with STATA version 14. We used Meta-XL (version  
128 2.2) to stabilize the variances of the raw proportions and pool proportions with a random-  
129 effects model ([http://www.epigear.com/index\\_files/metaxl.html](http://www.epigear.com/index_files/metaxl.html)).

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## Results

### *Characteristics of surveys and participants*

In all, 76 LMICs had GSHS and HBSC surveys between 2003 and 2013. Two surveys (Tajikistan and Zimbabwe) had no data on height and weight. **Table 1** shows the characteristics of the available 74 surveys. Due to poor availability of data on height and weight (i.e. <60%), 23% (17/74) of the countries were excluded from the analysis. By WHO region, per total number of LMICs (n=57), 7 (15%) of 47 in Africa, 15 of (50%) 30 in the Americas, 12 (80%) of 15 in the Eastern Mediterranean, 6 (35%) of 17 countries in Europe, 6 (60%) of 10 in Southeast Asia, and 11 (52%) of 21 in the Western Pacific had GSHS or HBSC survey data. Adolescents (n =129,276) had a mean age of 14.3 years (range: 13.3-14.9 years). The mean BMI was 20.3 kg/m<sup>2</sup> (range: 17.1 kg/m<sup>2</sup> in Sri Lanka to 24.9 kg/m<sup>2</sup> in Niue). The percentage of boys ranged from 39% in Swaziland to 66% in Benin. The mean overall response rate (total sample of students aged 12-15 years divided by the total sample of students with complete sex, age, and anthropometric data) was 87.3% (range: 63.1%-97.6%).

### *Prevalence of stunting*

The overall adolescent stunting prevalence was 10.2% (95% CI: 8.3, 12.2; I<sup>2</sup>: 99.3%) and ranged from 0% (Niue) to 38.0% (Myanmar) (**Figure 1**). Per region, the overall estimate was lowest for Europe at 5.5% and highest for South-East Asia at 19.8% [**Supplemental Table 2**]. In boys, stunting prevalence ranged from 1.8% (British Virgin Islands) to 45.2% (Yemen) with the regional estimate being lowest in the Western Pacific (7.9%)



and highest Africa (21.7%) [Supplemental Table 3]. In girls, the prevalence of stunting ranged from 0% (Niue) to 36.5% (Myanmar). The regional estimate of stunting in girls was lowest for the Western Pacific (5.0%) and highest for South-East Asia (18.2%) [Supplementary Table 4].

#### *Prevalence of thinness*

The overall prevalence of adolescent thinness was 5.5% (95% CI: 4.3, 6.9; I<sup>2</sup>: 99.0) and ranged from 0.0% (Nauru and Niue) to 31.5% (Sri Lanka) [Figure 2]. The regional estimate was lowest for the Americas (2.5%) and highest for South-East Asia (15.0%) [Supplemental Table 2]. Among boys, the prevalence of thinness ranged from 0.0% (Nauru and Niue) to 39.0% (Sri Lanka) with the regional estimate being lowest for the Americas (2.9%) and highest for South-East Asia (17.9%) [Supplemental Table 3]. In girls, the prevalence of thinness ranged from 0% (Nauru, Tonga and Niue) to 25.1% (Sri Lanka). The regional estimate of thinness in girls was lowest for the Western Pacific (1.8%) and highest for South-East Asia (12.4%) [Supplemental Table 4].

#### *Prevalence of overweight or obesity*

The overall prevalence of overweight or obesity in adolescents was 21.4% (95% CI: 18.6, 24.2; I<sup>2</sup>: 99.4%) and ranged from 4.8% (Sri Lanka) to 59.7% (Niue) [Figure 3]. The regional estimate was lowest for South-East Asia (11.1%) and highest for the Western Pacific (33.7%) [Supplemental Table 2]. In boys, the prevalence of overweight or

obesity ranged from 2.1% (Uganda) to 61.1% (Tonga) with the regional estimate being lowest for Africa (10.1%) and highest for the Western Pacific (31.8%) [Supplementary Table 3]. In girls, the prevalence of overweight or obesity ranged from 4.8% (Sri Lanka) to 63.5% (Niue). The regional estimate for overweight or obesity in girls was lowest for South-East Asia (9.8%) and highest for the Western Pacific (34.9%) [Supplemental Table 4].

#### *Prevalence of stunting and/or thinness*

Supplemental Table 5 shows the prevalence of **stunting and/or thinness** among adolescents. The overall prevalence of **stunting and/or thinness** in adolescents was 15.6% (95% CI: 13.2, 18.2;  $I^2$ : 99.4%) and ranged from 0% (Niue) to 50.6% (Yemen), with the regional estimate being lowest for the Western Pacific region (9.3%) and highest for South-East Asia (32.1%). In boys, the prevalence of **stunting and/or thinness** ranged from 0% (Niue) to 59.3% (Yemen) with the regional estimate being lowest for Europe (9.3%) and highest for South-East Asia (35.9%). In girls, the prevalence of **stunting and/or thinness** ranged from 0% (Niue) to 45.2% (Myanmar) with the regional estimate being lowest for the Western Pacific (7.5%) and highest for South-East Asia (28.9%).

#### *Overweight or obesity and thinness*

Figure 4 shows adolescent **overweight or obesity prevalence by stunting and/or thinness** prevalence. 16% (9/57) had **overweight or obesity prevalence and stunting and/or**

thinness prevalence greater than the overall pooled prevalence estimates for overweight or obesity and stunting and/or thinness prevalence, respectively. By WHO region, per total number of LMICs, 14% (1/7) in Africa, 7% (1/15) in the Americas, 17% (2/12) in the Eastern Mediterranean region, 33% (2/6) in Europe, 0% in South-East Asia and 9% (1/11) in the Western Pacific had overweight or obesity and stunting and/or thinness prevalences greater than their regional prevalence estimates for overweight or obesity and stunting and/or thinness (Supplemental Figures 1-6).

#### *Prevalence of concurrent stunting and overweight or obesity*

The overall prevalence of concurrent stunting and overweight or obesity in adolescents was 2.0% (95% CI 1.7, 2.5;  $I^2$ : 96.0%) and ranged from 0% (Niue) to 10.1% (Egypt) [Figure 5], with the regional estimate being lowest for Africa (1.2%) and highest in the Eastern Mediterranean region (3.4%) [Supplemental Table 6]. In boys, the prevalence of concurrent stunting and overweight or obesity ranged from 0% (Niue) to 12.7% (Egypt) with the regional estimate being lowest for Africa (1.3%) and highest for the Eastern Mediterranean region (4.1%) [Supplemental Table 6]. In girls, the prevalence of concurrent of stunting and overweight or obesity ranged from 0.0% (Niue) to 7.7% (Egypt) with the pooled regional estimate lowest for Africa (1.1%) and highest in the Eastern Mediterranean region (2.8%) [Supplemental Table 6].

### *Sources of Heterogeneity*

LMICs were heterogeneous ( $I^2 > 99\%$ ) in overall pooled estimates for adolescent stunting, thinness and overweight or obesity suggesting marked variation. Recent internal conflict ( $r = 0.46$ ,  $p = 0.002$ ), lack of democracy ( $r = 0.45$ ,  $p = 0.002$ ), and food insecurity ( $r = 0.43$ ,  $p = 0.004$ ) were positively correlated with stunting prevalence (**Supplemental Figures 7, 9 and 11**). GDP per capita was negatively correlated with stunting prevalence ( $r = -0.35$ ,  $p = 0.015$ ) [**Supplemental Figure 10**]. Similarly, recent internal conflict ( $r = 0.34$ ,  $p = 0.025$ ), lack of democracy ( $r = 0.26$ ,  $p = 0.017$ ), and food insecurity ( $r = 0.32$ ,  $p = 0.032$ ) were positively correlated with thinness prevalence (**Supplemental Figures 13, 15, and 17**). Year of survey ( $r = -0.26$ ,  $p = 0.049$ ) was negatively correlated with thinness prevalence (**Supplemental Figure 19**). Recent internal conflict ( $r = -0.48$ ,  $p < 0.001$ ) and food insecurity ( $r = -0.47$ ,  $p = 0.001$ ) were negatively correlated with overweight or obese prevalence (**Supplemental Figures 20 and 24**). GDP per capita ( $r = 0.42$ ,  $p = 0.002$ ) and urbanisation level ( $r = 0.33$ ,  $p = 0.014$ ) were positively correlated with overweight or obese prevalence (**Supplemental Figures 23 and 25**).

Up to 43.4% of the variance in stunting prevalence was accounted for by recent internal conflict, lack of democracy, GDP per capita and food insecurity; 38.4% of the variance in thinness prevalence was accounted for by recent internal conflict, lack of democracy, food insecurity, and survey year; and 58.7% of the variance in overweight or obesity prevalence was accounted for by recent internal conflict, GDP per capita, food insecurity,

urbanisation, and survey year.

## Discussion

We estimated the prevalence and distribution of the double burden of malnutrition among adolescents at both the population and individual level from 57 LMICs between 2003 and 2013. The prevalence of stunting and/or thinness among adolescents was 15.6% or about three in twenty adolescents; while 21.6% or about one in four adolescents were overweight or obese. A smaller proportion of adolescents also had concurrent stunting and overweight or obesity. There was significant heterogeneity in adolescent malnutrition prevalence estimates across LMICs; 38%-59% of the variance at the population level could be explained by macro-level contextual factors including internal conflict, lack of democracy, GDP, food insecurity, urbanisation and the year of survey.

No prior analyses have comprehensively examined the prevalence of the double burden of malnutrition among adolescents in LMICs at both the population and individual level and attempted to explain the heterogeneity of adolescent malnutrition prevalence estimates. For thinness and overweight or obesity, our results are not directly comparable with those of Abarca-Gómez et al (14) because the two studies covered different age ranges (5-19 years in Abarca-Gómez et al (14) study compared with 12-15 years in our study). However, both studies found thinness prevalence was highest in the South-East Asian region and overweight or obesity prevalence was highest in the Western Pacific region. We additionally showed concurrent stunting and overweight or obesity among

adolescents in LMICs was highest in the Eastern Mediterranean region. Inadequate nutrition in the period between conception and 2 years can lead to reduced linear growth (1). Given that resolution of these height deficits may take several generations (15), stunted children also exposed to obesogenic environments may be at greater risk at becoming overweight or obese. Stunting has been reported to alter body composition and fat distribution (e.g. via greater insulin sensitivity and/or lower fat oxidation) predisposing adolescents to excess adiposity (16).

The double burden of malnutrition poses an important challenge for governments in LMICs, in how limited resources are allocated. Double-duty actions (17) (which include interventions, programmes and policies) have the potential to simultaneously reduce the risk or burden of stunting, thinness and obesity. A key principle is to ensure that current actions designed to address one form of malnutrition do not unintentionally, increase the risk of another. For example, in LMICs, school food programmes emphasise children having enough food or encouraging school attendance (18). However, these programmes typically have limited guidance on nutritional quality. In the Americas, processed foods are widely served and many programmes lack adequate fresh foods and diet diversity (19). While evidence-based double-duty actions can offer an integrated approach to addressing malnutrition, they warrant adaptation to different contexts. We showed that a large proportion of the variance in adolescent malnutrition at the population level was explained by macro-level contextual factors. The macro-level context is rarely and

inconsistently examined when examining the double burden of malnutrition (14), creating challenges for policy makers and program planners who may play a key role in contextualizing double-duty actions.

Our study is not without limitations. Our only measure of adiposity was BMI, which may be affected by variation in lean mass. However, BMI is the most commonly used measure for monitoring the prevalence of overweight and obesity at the population level and is well correlated with more precise adiposity measures (20). Moreover, precise measures of adiposity are costly, time consuming, and not feasible for use in large population-based studies across continents (21). While we attempted to use all available GSHS or HSBC survey data, 23% of countries were excluded because of incomplete availability of anthropometric data. Thus, certain WHO regions are under-represented (particularly Africa) limiting the generalizability of our findings. Non-included countries had a higher prevalence of stunting (19.6%) and overweight or obese (30.4%). Our estimates of the prevalence of the double burden of malnutrition applies only to adolescents that attend school. While the GSHS and HBSC study are limited to adolescents attending school, only a third of countries had a median net secondary school enrolment rate of less than 50% (Supplemental Table 7) (22). Thus our results are most probably representative of most of the students in this age bracket in LMICs. Finally, while we were able to investigate the macro-level contextual factors as sources of heterogeneity for prevalence estimates across LMICs, the GSHS and HBSC study do not collect individual socio-

economic, ethnic or urban/rural data and thus we could not examine inequalities in prevalence across these subgroups. Despite these limitations, our study is the first to make comparable estimates of a complete set of anthropometric categories with clinical and public health relevance among adolescents in LMICs, in addition to examining the potential sources of heterogeneity in prevalence estimates. Our study also made use of a large amount of nationally representative adolescent anthropometric data based on standardized data collection methods across 57 LMICs.

In conclusion, the double burden of malnutrition among adolescents particularly at the population level is common in LMICs. A large proportion of the variance in adolescent malnutrition was explained by macro-level contextual factors. Without attending to context, interventions and programs for adolescent malnutrition in LMICs may fail or underperform.



312   **Acknowledgments**

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314   The authors' responsibilities were as follows—RC, APK, JBE designed the study; RC

315   and SS were in charge of data management and analyzed data. RC wrote the paper and

316   had primary responsibility for final content; APK, JBE, RU, GNT, SS, and JK provided

317   intellectual content to revise the manuscript; critically reviewed the manuscript. All

318   authors read and approved the final manuscript.

319   None of the authors reported a conflict of interest related to the study.

**Table 1** Characteristics of adolescents aged 12-15 years in low-income and middle-income countries (n=57)<sup>1</sup>

	Year	Sample Size, n	Coverage	Response Rate (%) <sup>2</sup>	Boys (%)	Age, years	BMI, kg/m <sup>2</sup>	Height, metres
African Region								
Algeria	2011	3387	National	96.0	46.0	14.1 ± 1.1	19.3 ± 3.3	1.6 ± 0.1
Benin	2009	1137	National	96.4	66.0	14.7 ± 0.9	19.5 ± 2.5	1.6 ± 0.1
Ghana	2012	1064	National	94.8	48.6	14.3 ± 1	19.1 ± 2.8	1.6 ± 0.1
Mauritania	2010	856	National	64.8	52.8	14.7 ± 0.9	20.2 ± 3.7	1.6 ± 0.1
Republic of Mauritius	2011	2974	National	94.8	48.5	14.3 ± 1.0	19.6 ± 4.2	1.6 ± 0.1
Sudan	2012	1302	National	88.2	51.8	14.7 ± 0.8	19.1 ± 3.9	1.5 ± 0.1
Swaziland	2013	1258	National	91.9	39.1	14.6 ± 0.9	20.4 ± 3.6	1.6 ± 0.1
Uganda	2003	1801	National	91.7	47.3	14.8 ± 0.8	19.1 ± 2.8	1.6 ± 0.1
Americas Region								
Argentina	2007	1067	National	67.9	46.9	14.7 ± 0.8	21.0 ± 3.3	1.6 ± 0.1
Belize	2011	1487	National	91.7	48.3	14.1 ± 1.1	21.8 ± 4.8	1.6 ± 0.1
Bolivia	2012	2682	National	90.7	49.8	14.5 ± 0.9	20.9 ± 3.3	1.6 ± 0.1
British Virgin Islands	2009	1106	National	91.6	47.6	14.0 ± 1.1	22.5 ± 6.1	1.6 ± 0.1
Chile	2004	5158	National	67.4	48.1	14.1 ± 1.0	20.8 ± 3.0	1.6 ± 0.1
Costa Rica	2009	2198	National	96.5	49.9	14.5 ± 0.8	21.2 ± 3.9	1.6 ± 0.1
Dominica	2009	1049	National	79.7	53.1	14.2 ± 1.1	21.3 ± 4.9	1.6 ± 0.1
Guatemala	2009	4286	National	93.5	52.1	14.5 ± 0.9	21.3 ± 3.9	1.5 ± 0.1
Guyana	2012	1896	National	95.5	48.3	14.6 ± 0.8	19.7 ± 3.9	1.6 ± 0.1
Honduras	2012	1422	National	94.7	46.0	14.1 ± 1.0	20.1 ± 3.9	1.6 ± 0.1
Jamaica	2010	1177	National	95.9	49.4	14.8 ± 0.7	21.2 ± 4.3	1.6 ± 0.1
Peru	2010	2143	National	90.3	50.1	14.6 ± 0.8	21.0 ± 2.8	1.5 ± 0.1
St. Kitts & Nevis	2011	1264	National	85.3	50.1	14.6 ± 0.8	22.0 ± 5.4	1.6 ± 0.1
Suriname	2009	997	National	93.9	44.5	14.5 ± 1.0	20.1 ± 4.1	1.6 ± 0.1
Uruguay	2012	2590	National	89.2	46.0	14.6 ± 0.8	21.2 ± 3.9	1.6 ± 0.1
Eastern Mediterranean Region								
Djibouti	2007	887	National	86.3	59.3	14.8 ± 0.8	19.5 ± 4.1	1.6 ± 0.1
Egypt	2011	2038	National	84.1	48.2	14.0 ± 0.9	21.1 ± 4.0	1.5 ± 0.1
Iraq	2012	1459	National	93.9	54.4	14.4 ± 1.0	20.7 ± 4.2	1.6 ± 0.1
Jordan	2007	1043	National	63.1	51.1	14.9 ± 0.7	20.5 ± 4.0	1.6 ± 0.1
Lebanon	2011	1359	National	68.1	49.9	14.2 ± 1.0	20.5 ± 3.7	1.6 ± 0.1
Libya	2007	1693	National	87.9	48.7	14.1 ± 1.0	20.5 ± 4.3	1.6 ± 0.1

Morocco	2010	2270	National	92.6	52.6	14.2 ± 1.0	19.3 ± 3.3	1.6 ± 0.1
Pakistan	2009	4808	National	96.1	60.9	14.6 ± 0.8	18.6 ± 2.7	1.6 ± 0.1
Palestine	2010	3904	Subnational	89.0	50.0	14.3 ± 0.9	20.3 ± 4.0	1.6 ± 0.1
Syria	2010	2799	National	95.2	51.0	14.1 ± 1.0	20.3 ± 3.8	1.6 ± 0.1
Yemen	2008	665	National	69.3	61.5	14.4 ± 0.9	18.5 ± 4.6	1.5 ± 0.1
European Region								
Bulgaria	2006	1704	National	93.5	50.8	13.5 ± 0.6	19.1 ± 3.1	1.6 ± 0.1
Macedonia	2007	1282	National	81.9	52.5	14.4 ± 0.9	20.3 ± 3.0	1.6 ± 0.1
Romania	2006	1648	National	94.4	44.9	13.5 ± 0.7	19.1 ± 3.2	1.6 ± 0.1
Russia	2006	2493	National	82.8	44.4	13.5 ± 0.6	19.0 ± 2.9	1.6 ± 0.1
Turkey	2006	2503	National	87.7	52.4	13.3 ± 0.9	18.8 ± 3.1	1.5 ± 0.1
Ukraine	2006	2134	National	91.2	52.1	13.4 ± 0.7	18.5 ± 2.8	1.6 ± 0.1
South-East Asia Region								
India	2007	6132	National	83.0	57.6	14.4 ± 0.9	18.6 ± 3.3	1.6 ± 0.1
Indonesia	2007	2285	National	75.5	47.1	14.3 ± 0.8	18.5 ± 3.2	1.5 ± 0.1
Malaysia	2012	15709	National	96.5	48.9	14.5 ± 0.8	20.4 ± 4.7	1.6 ± 0.1
Myanmar	2007	2000	National	89.1	48.1	14.2 ± 1.0	17.9 ± 2.7	1.5 ± 0.1
Sri Lanka	2008	2167	National	86.2	46.1	14.2 ± 0.9	17.1 ± 2.7	1.5 ± 0.1
Thailand	2008	2599	National	97.0	47.8	14.1 ± 1.0	19.6 ± 3.9	1.6 ± 0.1
Western Pacific Region								
China	2003	7341	Subnational	85.5	50.1	14.2 ± 1.0	19.5 ± 4.0	1.6 ± 0.1
Cook Islands	2011	794	National	93.2	48.4	14.2 ± 1.0	24.4 ± 5.2	1.7 ± 0.1
Fiji	2010	1388	National	92.3	47.8	14.5 ± 0.8	19.7 ± 4.0	1.6 ± 0.1
Kiribati	2011	1223	National	90.1	45.7	14.6 ± 0.9	22.4 ± 3.5	1.6 ± 0.1
Nauru	2011	336	National	87.3	50.4	14.2 ± 1.0	23.1 ± 4.4	1.5 ± 0.1
Niue	2010	80	National	97.6	55.4	13.9 ± 1.2	24.9 ± 5.2	1.7 ± 0.1
Philippines	2011	3488	National	89.8	47.0	14.4 ± 1.0	18.9 ± 3.5	1.5 ± 0.1
Samoa	2011	1490	National	67.3	47.3	14.5 ± 0.8	24.0 ± 5.3	1.6 ± 0.1
Solomon Islands	2011	782	National	79.9	51.3	14.6 ± 0.9	20.6 ± 3.4	1.6 ± 0.1
Tonga	2010	1874	National	95.7	50.4	14.6 ± 0.9	24.4 ± 4.8	1.6 ± 0.1
Vanuatu	2011	598	National	69.1	50.6	14.0 ± 1.1	18.8 ± 2.9	1.6 ± 0.1

<sup>1</sup> Values are means ± SDs unless otherwise indicated.

<sup>2</sup> Response rate = total sample of students aged 12-15 years divided by the total sample of students with complete sex, age, and anthropometric data

## Figure legends

Figure 1. Forest plot of stunting prevalence among adolescents aged 12-15 years in low-income and middle-income countries

Figure 2. Forest plot of thinness prevalence among adolescents aged 12-15 years in low-income and middle-income countries

Figure 3. Forest plot of overweight or obese prevalence among adolescents aged 12-15 years in low-income and middle-income countries

Figure 4. Scatterplot of **overweight or obese** prevalence by **stunting and/or thinness** prevalence among adolescents aged 12-15 years in low-income and middle-income countries

Figure 5. Forest plot of concurrent stunting and overweight or obesity among adolescents aged 12-15 years in low-income and middle-income countries

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