The Trend of Undernutrition Status for Female Youth in Low Income and Middle Income Countries from 1999 to 2009

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ABSTRACT

Despite the nutritional transition and food security issues in developing countries, nutritional status trend for female youth (15-24) is understudied in low and middle income countries. This study used 56 cross-sectional Demographic and Health Surveys from 23 countries grouped into three waves (1999, 2004 and 2009), to describe the trends of undernutrition (stunting and thinness/underweight) by demographics, and test the wave effect using fixed effect models.

We found that the nutritional trends for the female youth in low and middle income DHS countries differ by indicators: stunting rates decreased in most of the countries; whereas thinness/underweight rates increased in most of them from 1999 to 2009. The trends differ over country income levels: more middle income countries showed improvement on undernutrition indicators as compared to the low income countries for the same period. The trends also differ over waves: more countries had decreased undernutrition prevalence in 2004-2009 as compared to 1999-2004.

Trends of Stunting and Underweight among Female Youth in Low Income and Middle Income Countries during from 1999 to 2009

INTRODCUTION

Maternal and child undernutrition has been identified as major global health problem, especially in low income and middle income countries (Bryce et al., 2008), but the scope of energy-protein malnutrition issues in female youth population are not well understood. Energy-protein malnutrition or protein-calorie malnutrition often refers to undernutrition due to deficiency of protein and/or energy intake(Waterlow, 1976), though it also covers the condition of overnutrition(Ge & Chang, 2001). Undernutrition are often defined as stunting(for chronic malnutrition), wasting(for acute malnutrition), underweight(reflects both chronic and acute malnutrition) for child and adolescent (Chen, Chowdhury, & Huffman, 1980) (Deonis, Monteiro, Akre, & Clugston, 1993), and underweight for adult.

Undernutrition for women is associated with adverse impact on women's health and reproductive development(Chowdhury, Huffman, & Curlin, 1977). Furthermore, maternal undernutrition will influence pregnancy outcomes(Black et al., 2008) ,such as infant birth weight(Kramer, 1987) and intrauterine growth retardation(Sayers & Powers, 1997) and even mortality(Ozaltin, Hill, & Subramanian, 2010) .

Most of the literature related to nutritional status trend of women focuses on adulthood (Garenne, 2011), or children under 5 years old (de Onis & Blossner, 2000; Kerac et al., 2011; Mukuria, Cushing, & Sangha, 2005), with far less devoted to the adolescent and/or youth population.(Naude, Senekal, Laubscher, Carey, & Fein, 2011) Youth are a highly relevant population and a significant portion of childbearing occurs in low and middle income countries in adolescence and young adulthood(Sneeringer, 2009), thus monitoring their nutritional status is an important goal.

Low income and middle income countries are undergoing or about to experience transitional transitions (Amuna & Zotor, 2008), and have been suffered at different levels from the food security crisis in the first 10 years of 21 century (Godfray et al., 2010). Therefore, estimate the magnitude of undernutrition and monitor the nutritional trend for these countries will facilitate to inform collective actions and cope with these public health issues.

Our objective in this study is to describe and compare the recent trends of energy-protein undernutrition in low and middle income countries during the period from 1999 to 2009, using stunting and underweight as major nutritional indicators for chronic and acute malnutrition, based on anthropometry information in standard national Demographic and Health Surveys (DHS).

METHODS

Design and Data

We performed a secondary analysis using 56 standard cross-sectional Demographic and Health Surveys (DHS) from 23 countries. We grouped the DHS surveys intro three waves defined by chronological year, in order to create the comparable panels across countries. Surveys conducted during 1998-2000 were coded as one round (wave 1999); and those in 2003-2005 as the second round (wave 2004), and those in 2008-2010 as another round (wave 2009), so as to maximize the number of countries eligible for panel trend analysis. These countries were from Sub-Saharan Africa (n=14), North Africa/West Asia/Europe (n=3), South & Southeast Asia (n=3) and Latin America (n=3). We selected all the countries which had at least 2 surveys conducted during the waves that we defined. Furthermore, we grouped these countries into low income countries and middle income countries, according World Bank's latest categorization of countries in terms of gross national income per capita level. (World Bank, 2012)

Table 1 Available DHS surveys by country and wave

		Wave			total number of surveys
	Countries	**1999**	**2004**	**2009**	
Low income countries	Bangladesh	1	1	0	2
	Burkina Faso	1	1	0	2
	Ethiopia	1	1	0	2
	Guinea	1	1	0	2
	Haiti	1	1	0	2
	Kenya	1	1	1	3
	Cambodia	1	1	1	3
	Madagascar	0	1	1	2
	Malawi	1	1	1	3
	Rwanda	1	1	1	3
	Tanzania	0	1	1	2
	Zimbabwe	1	1	1	3
Middle income countries	Armenia	1	1	0	2
	Bolivia	1	1	1	3
	Cameroon	1	1	0	2
	Colombia	1	1	1	3
	Egypt	1	1	1	3
	Ghana	1	1	1	3
	India	1	1	0	2
	Lesotho	0	1	1	2
	Nigeria	1	1	1	3
	Senegal	0	1	1	2
	Turkey	1	1	0	2
Total		19	23	14	56

Sample

DHS started to collect anthropometry information of women above 15 years old since the second round (1989-1993). For this study, we restricted the analytical sample to female youth aged 15-24 years old and 15-18 years old sometimes due to the availability of WHO growth standards. We excluded pregnant females and those who had a birth within 2 months before the survey for weight related analysis, as standards for adolescent and adult women do not apply to this population. We also excluded some outlined cases according to convention rules. The weighted sample sizes for underweight analysis had the mean of 3807 (SD=5890, range: 227-40487), while those for stunting analyses had the mean of 5303(SD=6680, range: 274- 46762).

Variables and data handling

We developed our anthropometry nutritional indicators using height and weight of female youth based on WHO standards. Due to the lack of availability of international reference on weight over 10 years old population, our analyses focused on stunting and thinness/underweight.

Stunting and thinness for 15-18 years old (180-227 months old)

Stunting and thinness mainly reflect protein-energy malnutrition, which are determined based on Z-score of height (Height-for-age, HAZ) and BMI (BMI-for-age, BMIZ) measures normalized by the representative distribution for each age and gender group. Stunting reflects the past or chronic, long-term malnutrition; while thinness reflects both chronic and recent/acute malnutrition.

According to the WHO Child Growth Standards 2007(de Onis et al., 2007) for the 5-19 years old, stunting is defined as HAZ< -2SD, and moderate stunting as HAZ from -3SD> to <-2SD, and severe stunting as HAZ<-3SD[a]. Thinness is determined as BMIZ <-2SD, Severe thinness as BMIZ <-3SD[b]. Observations with HAZ beyond the range of +6 to -6 and BMIZ beyond the range of +5 to -5 were excluded. And there's no oedema information in DHS surveys, so every case were coded as no oedema.

Underweight for 19-24 years old

Since WHO growth references do not apply to adult population, as they have different nutritional profiles compared to younger population. Therefore, stunting and thinness are not appropriate measures for this age group. We thus focused the analysis on underweight for this age of female youth, as a recent or acute undernutrition indicator.

Underweight was determined as BMI (kg/m^2) values under 18.5 and severely underweight as BMI under 16, according the wide used rule for adults[c].Observations with height beyond the range of 2.05m to 1.30m, weight beyond 200kg to 30k, BMI beyond 60 to 12 were excluded from analysis.

[a] http://www.who.int/growthref/who2007_height_for_age/en/index.html

[b] http://www.who.int/growthref/who2007_bmi_for_age/en/index.html

[c] http://apps.who.int/bmi/index.jsp?introPage=intro_3.html

Analysis

Analyses were conducted using Stata SE/11 statistical software and WHO provided Stata package related to child development standards. We perfumed the analyses for stunting and underweight separately. We first presented the estimated overall prevalence rates and trends of undernutrition indicators for each country during the three waves of surveys. We secondly counted the number of countries by their different trends and country income status. Thirdly, we tabulated the percentage of each indicator by wave, age, residence (urban/rural), wealth quintile, and country income status; and then summarized the trend of nutritional indicators by wave, age, residence, wealth quintile and country income status, using box plots. In the end, we conducted a serious of fixed effect models on each nutritional outcome to test the effect of time/wave of survey. The results from the models might be limited due to small sample size of countries, but useful to describe the time trend accounting for the variance between countries.

In addition to the analyses above, we applied the "Integrated Food Security Phase Classification (IPC)" as a reference[d] to understand its trend for acute malnutrition. This reference categorized areas into 5 stages of acute food insecurity according to regional nutrition status due to food deficit. Standards for BMI could be used to categorize the countries, which was "Phase 1: No Acute Food Insecurity" --BMI < 18.5 Rates: <10%; "Phase 2: Stressed" --BMI < 18.5 Rates: 10-20%, unstable; "Phase 3: Crisis --BMI < 18.5 Rates: 20-40%, 1.5 x greater than reference; "Phase 4: Emergency" -- BMI < 18.5 Rates: > 40%; "Phase 5: Catastrophe" --BMI < 18.5 Rates: far> 40%. We expand the "BMI < 18.5 rates" as underweight/thinness rates to include younger youth population in the analysis.

RESULTS

Trend of Stunting at Country Level

The top part of Table 2 presented the stunting prevalence for youth aged 15-18 years old by country. The media stunting prevalence was 11.4% (ranged from 3.1% to 50.0%, n=19) among the 1999 wave surveys, and 11.3% (ranged from 2.1% to 42.2%, n=23) in 2004 wave and 15.6% (ranged from 1.9% to 36.2%, n=14) in 2009 wave. Countries kept the high level of stunting prevalence (>=20%) in all available surveys were Bangladesh, India, Madagascar, Bolivia, Cambodia and Rwanda, ranked by average prevalence of all available waves from high to low. Senegal and Burkina Faso kept the stunting prevalence lower than 5% during available waves.

The median change of prevalence from the 2009 wave surveys to the 1999 surveys wave was -4.8% (ranged from -15.4% to 4.3%, n=10), and-3.0% (ranged from -14.0% to 5.1%, n=19) from 2004 to 1999, and -0.7% (ranged from -6.4% to 3.3%, n=14) from 2009 to 2004. Overall, the largest improvement took

[d] http://www.fews.net/ml/en/info/pages/scale.aspx

place in Bolivia, Nigeria, India and Colombia, the stunting rates of which decreased by at least 10% from 1999 to 2004. Among them, Bolivia and Columbia had the steady decreasing trend from 1999 to 2009; Nigeria's stunting rate increased from 2004 to 2009, instead; and India was lacking the 2009 wave survey. Most countries improved on stunting rate during 1999 to 2009, except for Rwanda.

The bottom half of Table 2 presented the prevalence of severe stunting for youth aged 15 to 18 years by each country. The median severe stunting rate was1.8% (ranged 0% to 15.6%, n=19) in the 1999 wave survey, and 1.2% (ranged 0 to 7.9%, n=23) in 2004, and 2.0% (ranged 0.3% to 7.3%, n=14) in 2009. Overall, countries kept high severe stunting rates (>=5%) over the three waves were India, Bangladesh and Madagascar, ranked by mean rate from high to low. Turkey kept the longest rate for severe stunting over the waves, which was 0%.

The median change of severe stunting rate was -0.6% (ranged -6.8% to 1.0%, n=10) from 2009 to 1999, and -0.4% (ranged -9.8% to 1.5%, n=19) from 2004 to 1999, and 0.1% (ranged from -2.4% to 1.1%, n=14) from 2009 to 2004. The largest decreases of severe stunting rates were in India and Nigeria from 1999 to 2004, though that for Nigeria youth increased slightly from 2004 to 2009. Most countries improved on stunting rate during 1999 to 2009, except for Rwanda.

Table 2 Prevalence rates of stunting and severe stunting for female youth in DHS low and middle income countries by country and wave*

		Wave			Change		
		1999	2004	2009	2004-1999	2009-2004	2009-2004
Stunting							
Low income countries	Bangladesh	50.0	42.2		-7.8		
	Burkina Faso	3.1	4.0		0.9		
	Cambodia	29.2	33.3	27.0	4.1	-6.4	-2.3
	Ethiopia	20.5	16.9		-3.5		
	Guinea	7.1	7.5		0.3		
	Haiti	7.2	6.4		-0.8		
	Kenya	9.7	9.4	8.5	-0.2	-1.0	-1.2
	Madagascar		33.1	36.2		3.1	
	Malawi	19.8	20.3	16.8	0.5	-3.4	-3.0
	Rwanda	19.5	24.6	23.9	5.1	-0.7	4.3
	Tanzania		18.8	18.1		-0.6	
	Zimbabwe	8.7	5.7	6.7	-3.0	1.0	-2.1
Middle income countries	Armenia	6.1	5.8		-0.3		
	Bolivia	39.7	25.7	24.3	-14.0	-1.4	-15.4
	Cameroon	6.4	5.9		-0.5		
	Colombia	22.6	11.3	9.2	-11.3	-2.1	-13.3
	Egypt	9.0	5.8	8.0	-3.3	2.2	-1.1
	Ghana	11.4	7.9	6.4	-3.6	-1.5	-5.1
	India	45.4	34.1		-11.3		
	Lesotho		12.9	14.4		1.5	
	Nigeria	26.7	14.8	18.1	-11.9	3.3	-8.6
	Senegal		2.1	1.9		-0.2	
	Turkey	9.5	2.8		-6.7		

Severe Stunting							
Low income countries	Bangladesh	9.4	7.7		-1.7		
	Burkina Faso	0.0	0.7		0.7		
	Cambodia	3.8	5.3	2.9	1.5	-2.4	-1.0
	Ethiopia	4.4	3.2		-1.2		-0.4
	Guinea	0.3	0.8		0.5		
	Haiti	0.7	0.8		0.1		
	Kenya	2.4	1.2	2.0	-1.2	0.7	
	Madagascar		8.0	7.3		-0.6	-0.5
	Malawi	2.3	3.1	2.1	0.8	-0.9	
	Rwanda	4.1	5.2	5.1	1.1	-0.1	-0.1
	Tanzania		2.9	3.1		0.2	1.0
	Zimbabwe	1.8	0.7	0.6	-1.1	-0.1	
Middle income countries	Armenia	0.3	0.1		-0.1		-1.2
	Bolivia	3.2	2.1	2.8	-1.1	0.7	
	Cameroon	0.0	0.6		0.6		
	Colombia	1.3	1.0	0.7	-0.4	-0.2	-0.6
	Egypt	1.5	0.2	0.4	-1.3	0.2	-1.1
	Ghana	1.8	0.8	1.3	-1.0	0.4	-0.5
	India	15.6	5.9		-9.8		
	Lesotho		2.5	1.5		-0.9	
	Nigeria	11.5	3.5	4.7	-7.9	1.1	-6.8
	Senegal		0.1	0.3		0.2	
	Turkey	0.0	0.0		0.0		

*15 to 18 years old population

Trend of Stunting by Country Income Status and Demographics

Table 3 showed that the stunting and severe stunting rate decreased in 50% or more countries during the 1999-2009. However, there were more countries improved on stunting rate in the middle income group as compared to those in the low income group. Furthermore, there seemed to be a different trend among low income and middle income countries,

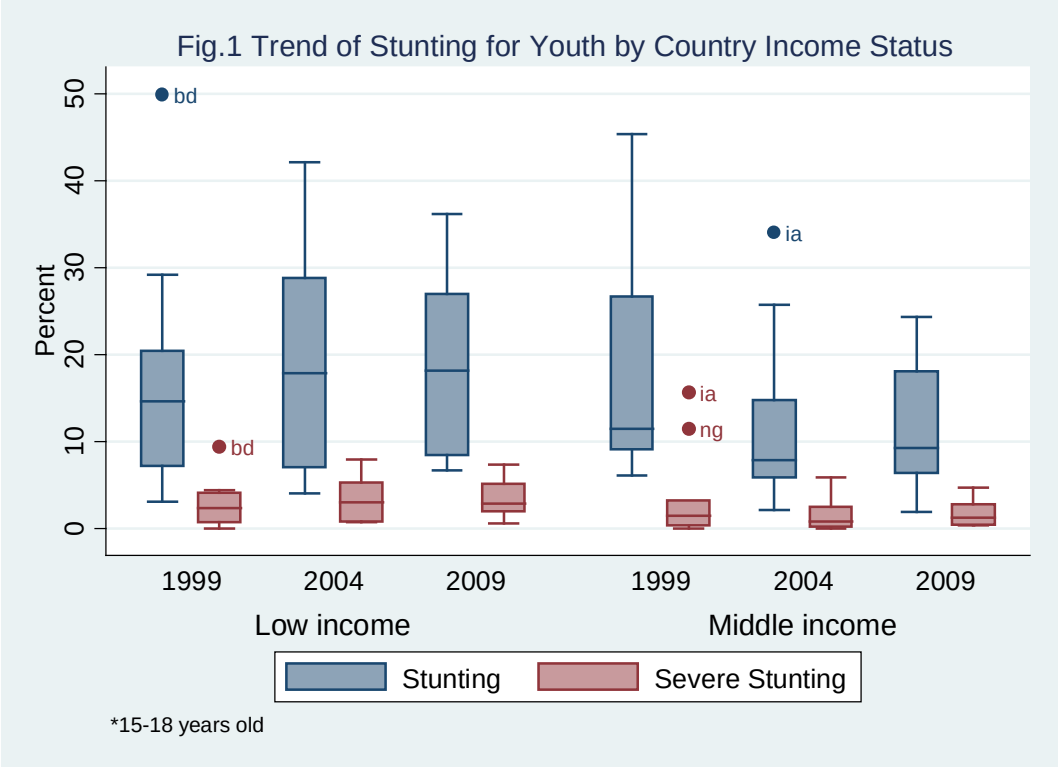
Table 3 Changes of stunting rates among low and middle income countries, 1999-2009 *

		2004-1999			x^2 test	2009-2004			x^2 test
		decreased	increased	total	p-values	decreased	increased	total	p-values
Stunting	Low income	5	5	10	p<0.05	5	2	7	ns**
	Middle income	9	0	9		4	3	7	
	total	14	5	19		9	5	14	
Severe Stunting	Low income	4	6	10	p=0.057	5	2	7	ns**
	Middle income	7	1	8		2	5	7	
	total	11	7	18		7	7	14	

note *: 15-18 years old; **ns: p-values>0.05, same in the following context

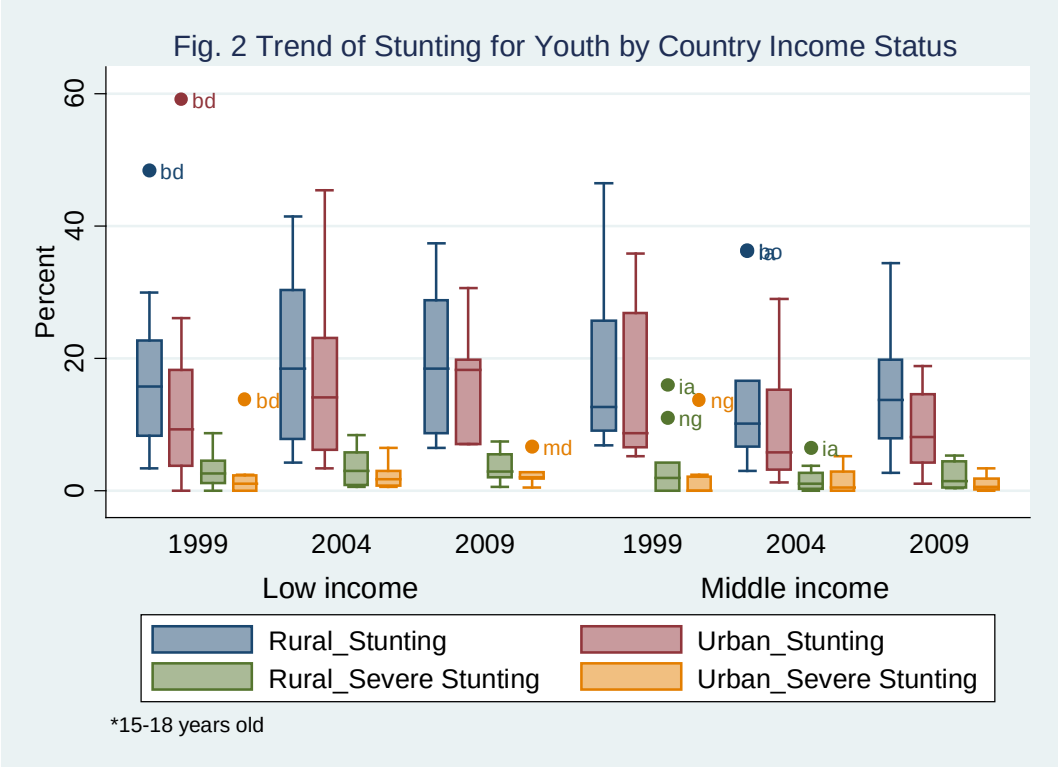
Figure 1 to Figure 3 summarized the percent of stunting and severe stunning among low income and middle income countries for different demographic groups. Given large deviance between countries, we will focus on the median rate for stunting and severe stunting to describe the trend.

According to figure 1, for female youth aged 15-18 years old, the median percentage of stunting is increased from 15% in 1999, to around 18% and stayed until 1999 in low income countries. But in high income countries, the median stunting rate decreased from about 11% in 1999 to 8% in 2004 and returned to around 9% in 2009. The median percentages for severe stunting were much lower than those for severe stunting, generally lower than 5%. But their trend patterns over time were similar. Bangladesh, India and Nigeria stood out to for their outlined stunting prevalence and/or severe prevalence in 1999.



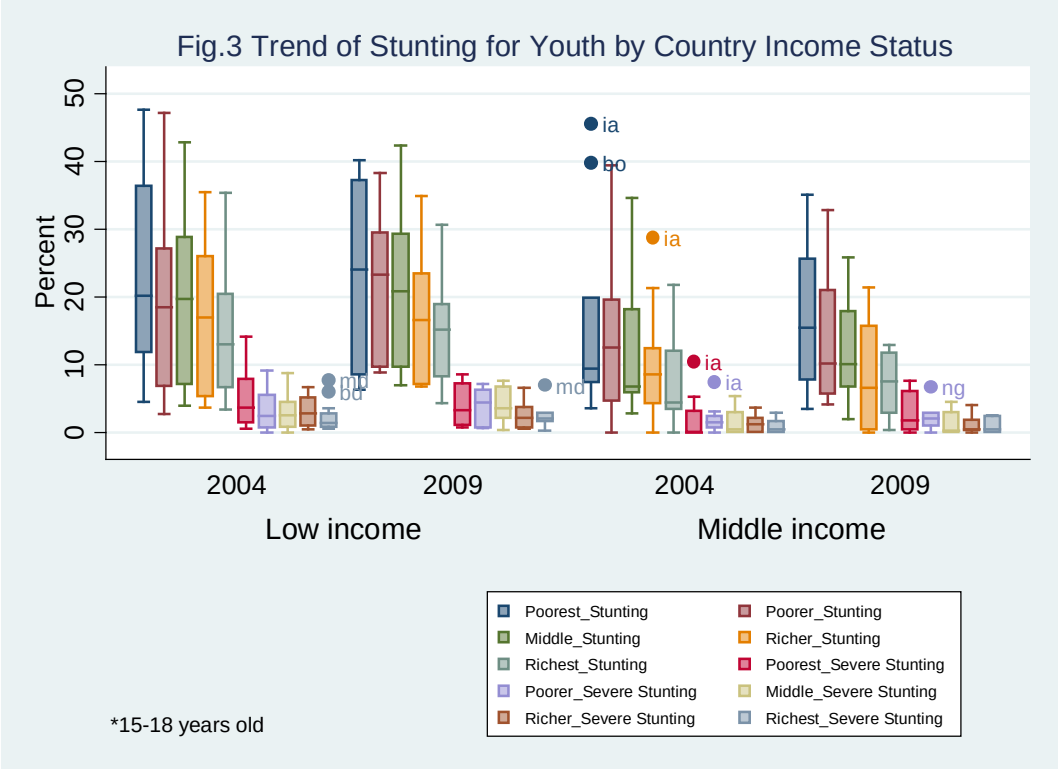
Note for country names: bd=Bangladesh; bf=Burkina; et=Cambodia; gn=Ethipia; ht=Guinea; ke=Haiti; kh=Kenya; md=Madagascar; mw=Malawi; rw=Rwanda; tz=Tanzania; zw=Zimbabwe; am=Armenia; bo=Bolivia; cm=Cameroon; co=Colombia; eg=Egypt; gh=Ghana; ia=India; ls=Lesotho; ng=Nigeria; sn=Senegal; tr=Turkey

According to figure 2, for female youth living in rural and urban area, the median percentage of stunting and severe stunting followed the similar pattern trend as the whole population's showed in figure 1. Additionally, the median rural stunting prevalence was usually higher than that for the urban, except for the wave around 2009 of low income coteries, where the median urban stunting rate caught up with the rural level.



Note for country names: bd=Bangladesh; bf=Burkina; et=Cambodia; gn=Ethipia; ht=Guinea; ke=Haiti; kh=Kenya; md=Madagascar; mw=Malawi; rw=Rwanda; tz=Tanzania; zw=Zimbabwe; am=Armenia; bo=Bolivia; cm=Cameroon; co=Colombia; eg=Egypt; gh=Ghana; ia=India; ls=Lesotho; ng=Nigeria; sn=Senegal; tr=Turkey

According to figure 3, the median stunting rate increased in every wealth quintile group from 2004 to 2009 in low income countries. But the median urban stunting rate had different trend for various wealth quintile groups. The median rates for poorer and richer group dropped about 2-3% during the two waves. In both groups the rate for the poorest group increased about 5%, faster than other groups.



Note for country names: bd=Bangladesh; bf=Burkina; et=Cambodia; gn=Ethipia; ht=Guinea; ke=Haiti; kh=Kenya; md=Madagascar; mw=Malawi; rw=Rwanda; tz=Tanzania; zw=Zimbabwe; am=Armenia; bo=Bolivia; cm=Cameroon; co=Colombia; eg=Egypt; gh=Ghana; ia=India; ls=Lesotho; ng=Nigeria; sn=Senegal; tr=Turkey

Trend of Thinness and Underweight by Country level

The top half of Table 4 presented the prevalence rate of thinness/underweight for youth aged 15-24 years old at country level. The median prevalence of thinness/underweight is 7.2% (range from 0.9% to 35.1%, n=19) in 1999 wave, and 7.0% in (ranged from 0.8% to 27.9%, n=23) in 2004, and 5.0% (ranged from 1.0% to 13.3%, n=14) in 2009. Countries with high level of prevalence of underweight/thinness were Bangladesh and India. Those with the lowest prevalence were Egypt and Bolivia.

The median change of prevalence of underweight/thinness was -0.02% (ranged from -7.4% to 3.3%, n=10) for the 2009 wave as compared to the 1999 wave, and -0.1% (ranged from -8.4% to 18.2%, n=19) for the 2004 wave as compared to the 1999 wave, and -0.05% (ranged from -1.9% to 6.1%, n=14) from 2009 to 2004. The largest decreases were in India from 1999 to 2004 and Senegal from 2004 to 2009. The largest decreased happened in Bangladesh and Ghana from 1999 to 2004.

The bottom half of Table 4 presented the prevalence of severe underweight/thinness for female youth aged 15 to 24 years old by country. The median of prevalence of severe underweight and thinness is 0.7% (ranged from 0.1% to 3.8%, n=19) in 1999, and 0.6% (ranged from 0.03% to 4.3%, n=23) in 2004 and 0.4% (ranged from 0 .04% to 3.2%,

n=14) in 2009. Countries with comparatively high level of severe underweight/thinness were Bangladesh and India. More than half of the countries kept their severe underweight/thinness rate under 1% during in the available surveys, such as Rwanda and Colombia.

The median change of severe underweight/thinness rate for female youth was -0.1% (ranged from -1.8% to 0.1%, n=10) from 2009 to 1999, and -0.03% (ranged -1.3% to 3.1%, n=19) from 2004 to 1999, and -0.1% (ranged from -0.4 to 1.8%, n=14) from 2009 to 2004. The largest changes increases were in India and Turkey from 1999 to 2004. While the largest drop were in Nigeria from 1999 to 2004.

Table 4 Prevalence rate of underweight/thinness for each country by wave and the changes between waves*

		Wave			Change		
		1999	2004	2009	2004-1999	2009-2004	2009-1999
Underweight/Thinness							
Low income countries	Bangladesh	35.1	26.8		-8.4		
	Burkina Faso	10.5	11.5		1.1		
	Cambodia	10.0	12.0	13.3	2.0	1.3	3.3
	Ethiopia	17.6	14.4		-3.2		
	Guinea	8.7	8.3		-0.5		
	Haiti	7.0	9.8		2.8		
	Kenya	10.3	7.1	7.9	-3.2	0.8	-2.4
	Madagascar		11.5	14.3		2.8	
	Malawi	5.0	5.9	5.0	1.0	-0.9	0.1
	Rwanda	3.6	3.3	2.7	-0.2	-0.7	-0.9
	Tanzania		5.5	5.7		0.2	
	Zimbabwe	3.4	5.6	5.1	2.2	-0.6	1.7
Middle income countries	Armenia	3.7	7.0		3.3		
	Bolivia	0.9	1.4	1.8	0.5	0.3	0.9
	Cameroon	7.2	4.1		-3.1		
	Colombia	4.0	4.9	4.0	0.9	-0.9	0.0
	Egypt	0.9	0.8	1.0	-0.1	0.2	0.1
	Ghana	12.3	5.1	4.8	-7.2	-0.3	-7.4
	India	9.8	28.0		18.2		
	Lesotho		4.1	3.3		-0.8	
	Nigeria	14.9	9.8	8.0	-5.0	-1.9	-6.9
	Senegal		12.9	19.0		6.1	
	Turkey	3.8	3.1		-0.6		
Severe Underweight/Thinness							
Low income countries	Bangladesh	3.8	2.9		-1.0		
	Burkina Faso	0.5	1.3		0.8		
	Cambodia	1.1	0.7	1.0	-0.4	0.3	-0.1
	Ethiopia	2.1	1.7		-0.4		
	Guinea	0.6	0.6		0.1		

	Haiti	0.8	0.7		0.0		
	Kenya	0.5	0.6	0.4	0.1	-0.2	-0.1
	Madagascar		0.5	1.4		1.0	
	Malawi	0.5	0.6	0.5	0.1	-0.2	0.0
	Rwanda	0.6	0.2	0.1	-0.3	-0.1	-0.4
	Tanzania		0.5	0.3		-0.2	
	Zimbabwe	0.2	0.7	0.3	0.5	-0.4	0.1
	Armenia	0.3	0.5		0.1		
	Bolivia	0.9	0.1	0.0	-0.8	0.0	-0.8
	Cameroon	1.2	0.4		-0.8		
	Colombia	0.4	0.4	0.2	0.0	-0.1	-0.2
Middle	Egypt	0.9	0.0	0.1	-0.8	0.1	-0.7
income	Ghana	0.7	0.5	0.6	-0.2	0.1	-0.1
countries	India	1.2	4.3		3.2		
	Lesotho		0.6	0.3		-0.3	
	Nigeria	2.5	1.1	0.7	-1.3	-0.5	-1.8
	Senegal		1.4	3.2		1.8	
	Turkey	0.1	3.1		3.0		

*15 to 24 years old population

Trend of Thinness and Underweight by Country Income Status

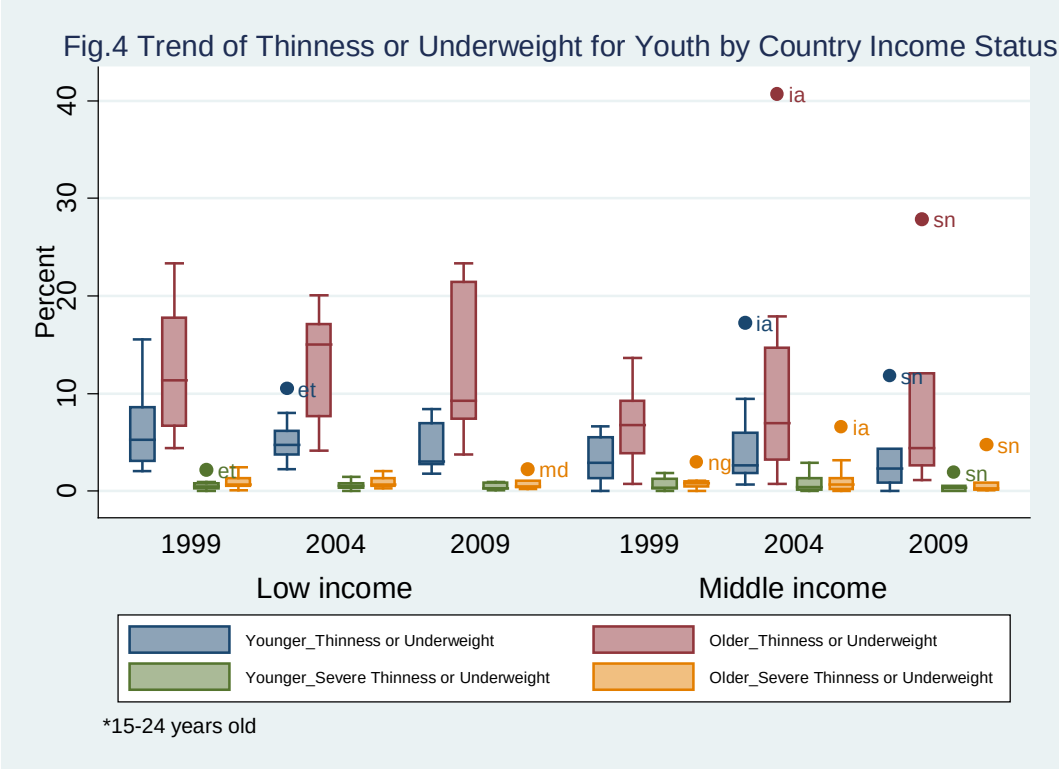
Table 5 showed that the thinness/underweight rate increased in more than 47% countries during 1999-2004, and in more than 78% countries during 2004-2009. However, the increasing trend was more to be observed in low income countries though not significant. Table 7 presented the prevalence rate and the changes for each country.

Table 5 Changes of thinness/underweight rates among low and middle income countries, 1999-2009

		2004-1999			x^2 test	2009-2004			x^2 test
		decreased	increased	total	p-values	decreased	increased	total	p-values
Thinness/	Low income	3	7	10	ns	2	5	7	ns
Underweight	Middle income	5	4	9		1	6	7	
	total	8	11	19		3	11	14	
Severe	Low income	4	6	10	ns	0	7	7	ns
Thinness/	Middle income	6	5	11		2	5	7	
Underweight	total	10	9	19		2	12	14	

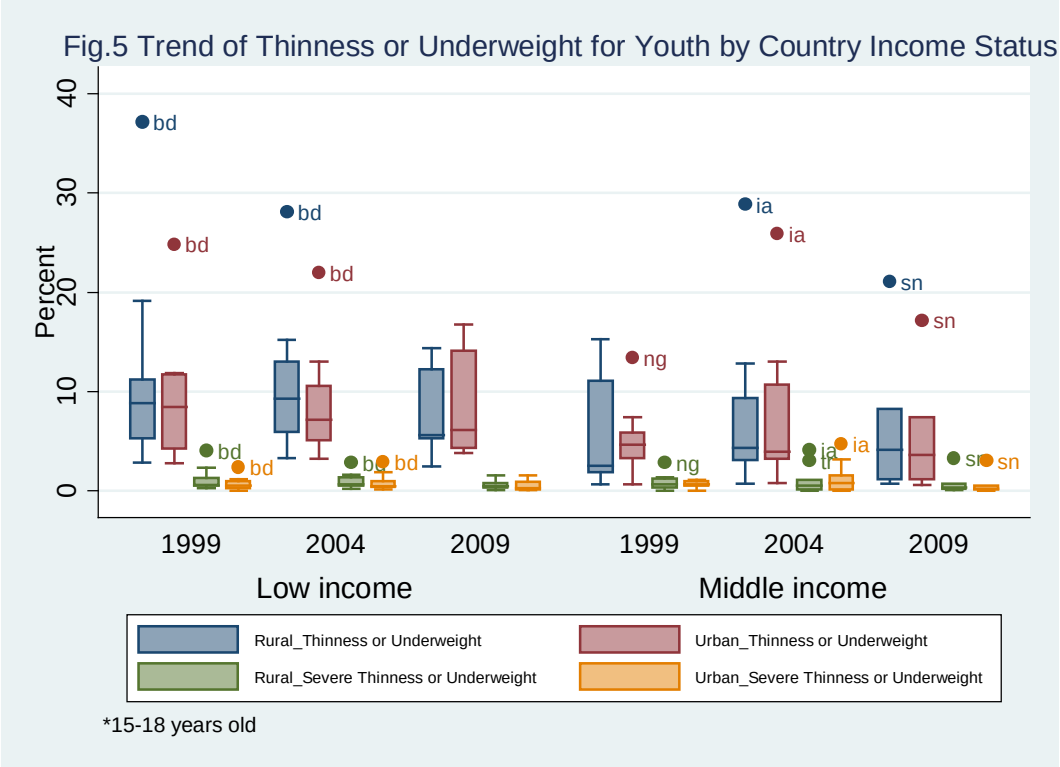
According to figure 4, the median underweight rate for older youth was usually higher than that for thinness among younger youth. Since the measures were calculated differently, the difference might come from the measurement methods. However, the median rates among low income countries were still higher than those in middle income countries. The rates for older youth in low income countries had the highest median among all groups, which was about 15%. Median rates for severe thin or

underweight stayed very low, about or less than 1%. India and Senegal were the high outliers among the middle income countries; while Ethiopia and Madagascar were the high outliers among the low income countries.



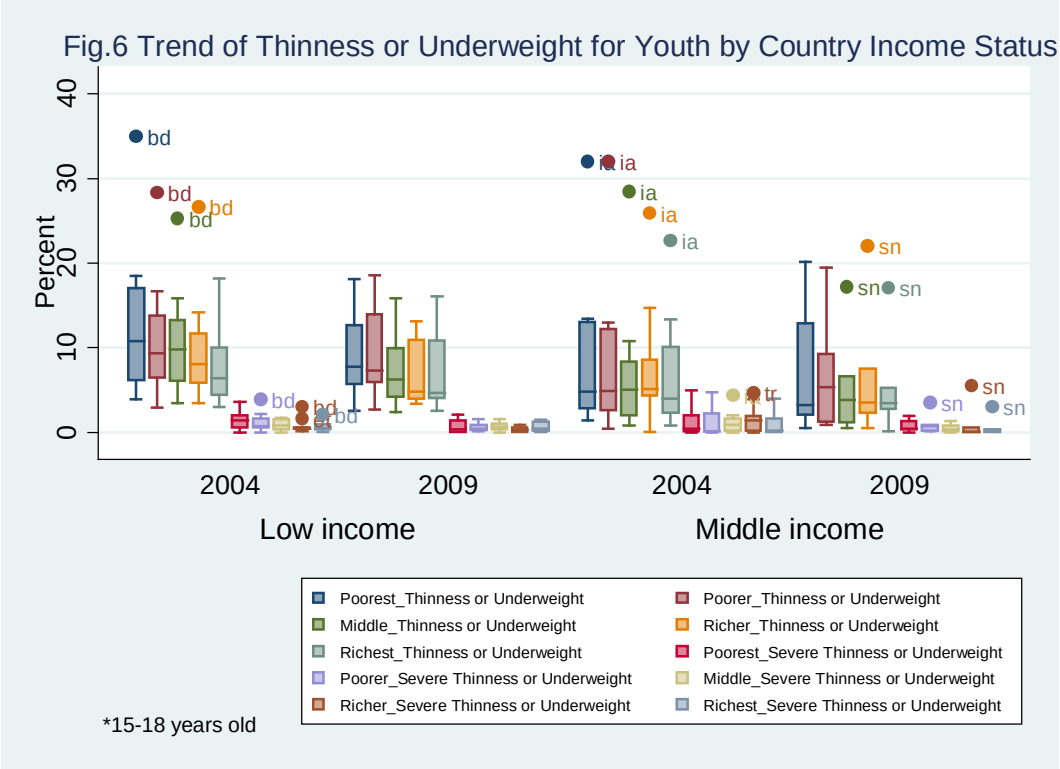
Note for country names: bd=Bangladesh; bf=Burkina; et=Cambodia; gn=Ethipia; ht=Guinea; ke=Haiti; kh=Kenya; md=Madagascar; mw=Malawi; rw=Rwanda; tz=Tanzania; zw=Zimbabwe; am=Armenia; bo=Bolivia; cm=Cameroon; co=Colombia; eg=Egypt; gh=Ghana; ia=India; ls=Lesotho; ng=Nigeria; sn=Senegal; tr=Turkey

According to figure 5, the median rates for rural and urban thinness or underweight rates were similar. The pattern of median rate might be influenced by the extremely higher rates for Bangladesh, India and Senegal.



Note for country names: bd=Bangladesh; bf=Burkina; et=Cambodia; gn=Ethipia; ht=Guinea; ke=Haiti; kh=Kenya; md=Madagascar; mw=Malawi; rw=Rwanda; tz=Tanzania; zw=Zimbabwe; am=Armenia; bo=Bolivia; cm=Cameroon; co=Colombia; eg=Egypt; gh=Ghana; ia=India; ls=Lesotho; ng=Nigeria; sn=Senegal; tr=Turkey

According to figure 6, there's more clear wealth gradient of median rates for thinness or underweight among low income countries as compared to middle income countries. Bangladesh, India and Senegal still stood up as outliers on the higher end.



Note for country names: bd=Bangladesh; bf=Burkina; et=Cambodia; gn=Ethipia; ht=Guinea; ke=Haiti; kh=Kenya; md=Madagascar; mw=Malawi; rw=Rwanda; tz=Tanzania; zw=Zimbabwe; am=Armenia; bo=Bolivia; cm=Cameroon; co=Colombia; eg=Egypt; gh=Ghana; ia=India; ls=Lesotho; ng=Nigeria; sn=Senegal; tr=Turkey

According to figure 7, the median overweight rates for older youth were slightly higher than those for the younger youth. Again, the difference might also come from measurement methods. Although the level of overweight was lower in low income countries as compared to middle income countries, the increasing speed of it in low income countries increasing,, while that for middle income counties was steady. Egypt's outlining overweight rate might be that they sampled only married women.

Food security categorization using IPC reference

Table 6 showed that over 20% countries were at " Stressed Food Insecure" during 1999, 2004 and 2009 wave, and over 5% and over 8% were at "Acute Food and Livelihood Crisis" IPC food security phase. Percent of countries at "Stressed Food Insecure"/ "Acute Food and Livelihood Crisis" IPC phase reduced from 37% in 1999 wave to 30% in 2004 wave, and to 21% in 2009 wave.

Table 6 IPC Food security phase of low and middle income countries, 1999, 2004, 2009

	Wave																	
	1999						2004						2009					
	Low income		Middle income		Total		Low income		Middle income		Total		Low income		Middle income		Total	
	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%	n	%
Phase 1: No Acute Food Insecurity	5	50	7	77.8	12	63.2	7	58.3	9	81.8	16	69.6	5	71.4	6	85.7	11	78.6
Phase 2: Stressed -- BMI < 18.5 Rates: 10-20%	4	40	2	22.2	6	31.6	4	33.3	1	9.1	5	21.7	2	28.6	1	14.3	3	21.4
Phase 3: Crisis — BMI < 18.5 Rates: 20-40%	1	10	0	0	1	5.3	1	8.3	1	9.1	2	8.7	-	-	-	-	-	-
Total	10	100	9	100	19	100	12	100	11	100	23	100	7	100	7	100	14	100

Discussion

Our study found that the **trends of energy protein undernutrition rate among the low and middle income countries were not at even pace or even monotonous in the 10 years.** The trend is changing over time, but not necessarily getting improved during all time period.

The overall undernutrition trend varied on nutritional measures. For stunting hugely more than half of the countries improved during 1999-2004 and 2004-2009. For severe stunting, although slightly more than half of the countries improved on this measure during 1999-2004, only half of the countries improved during 2004-2009. This indicates that the long term/chronic undernutrition among women improved in these low and middle income countries, but the long term severe undernutrition did improved as much as mild and moderate undernutrition conditions. For thinness and underweight, more countries became worse during 1999-2004 and 2004-2009. For severe thinness/underweight, about half of the countries improved during 1999-2004, but largely more countries got worse during 2004-2009. This indicates that acute undernutrition didn't improved much during the 10 years, and even worse more severe among these DHS low and middle income countries. **Overall, this indicate that, the regress on acute undernutrition conditions became more prevalent in these low and middle DHS countries, while the improvement of chronic undernutrition conditions became less prevalent among these countries during the 10 years.**

The trends were different among low and middle income countries. Overall all, low income countries were showing less improvement on undernutrition as compared to middle income countries in most cases. From the 1999 wave to 2004 wave, more middle income countries improved on stunting and

severing rates as compared to low income countries in our sample. From 2004 to 2009, slight more low income countries improved on stunting and severe stunting rate as compared to middle income countries, though not statistically significant. And there was a higher percentage of low income countries got worse during 1999-2004 as compared to that for middle income countries, though not statistically significant.

Appendix

Table 7 Fixed effect models if wave effect on stunting rate

Indicators		1999 vs. 2004		2009 vs. 2004	
By wealth	By Income Group	coefficient	p-values	coefficient	p-values
Stunting					
Rural	total	2.87	<0.01	-0.50	ns
	low income	0.85	ns	-0.74	ns
	middle income	5.12	<0.001	-0.18	ns
Urban	total	3.55	<0.05	-1.19	ns
	low income	0.16	ns	-0.70	ns
	middle income	7.74	<0.01	-1.37	ns
Younger	total	3.70	<0.01	-0.58	ns
	low income	0.63	ns	-0.60	ns
	middle income	7.09	<0.001	-0.43	ns
Severe stunting					
Rural	total	1.05	<0.05	0.00	ns
	low income	0.15	ns	-0.51	ns
	middle income	2.05	<0.05	0.53	ns
Urban	total	0.74	ns	-0.27	ns
	low income	0.29	ns	0.27	ns
	middle income	1.29	ns	-0.77	ns
Younger	total	1.11	<0.05	-0.10	ns
	low income	0.08	ns	-0.37	ns
	middle income	2.26	<0.05	0.22	ns

Table 8 Fixed effect models if wave effect on Thinness/Underweight

Indicators		1999 vs. 2004		2009 vs. 2004	
By wealth	By Income Group	coefficient	p-values	coefficient	p-values
Thinness/Underweight					
Older	total	-1.75	ns	0.39	ns
	low income	-0.56	ns	1.47	ns
	middle income	-3.06	ns	-0.74	ns
ALL	total	0.19	ns	0.01	ns
	low income	0.71	ns	0.76	ns
	middle income	-0.39	ns	-0.76	ns
Rural	total	0.14	ns	0.00	ns
	low income	0.50	ns	0.42	ns
	middle income	-0.26	ns	-0.43	ns
Urban	total	-0.44	ns	0.15	ns
	low income	0.70	ns	1.73	ns
	middle income	-1.70	ns	-1.47	ns
Younger	total	0.16	ns	-0.10	ns
	low income	1.26	ns	0.11	ns
	middle income	-1.05	ns	-0.36	ns
Severe Thinness/Underweight					
Older	total	-0.16	ns	0.01	ns
	low income	0.00	ns	0.17	ns
	middle income	-0.33	ns	-0.15	ns
ALL	total	-0.03	ns	-0.07	ns
	low income	0.09	ns	0.04	ns
	middle income	-0.16	ns	-0.20	ns
Rural	total	0.03	ns	-0.02	ns
	low income	0.13	ns	0.05	ns
	middle income	-0.08	ns	-0.09	ns
Urban	total	-0.34	ns	-0.19	ns
	low income	-0.18	ns	-0.01	ns
	middle income	-0.51	ns	-0.38	ns
Younger	total	-0.07	ns	-0.08	ns
	low income	0.00	ns	-0.11	ns
	middle income	-0.14	ns	-0.05	ns

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