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# Determinants of overweight with concurrent stunting among Ghanaian children

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## Abstract

**Background:** Malnutrition (undernutrition and overnutrition) is a major public health problem in Ghana –affecting growth and development of individuals and the nation. Stunting and overweight are of particular interest, as recent national surveys show a rising trend of overnutrition and stubbornly high burden of stunting among Ghanaian children. There are currently no data on the simultaneous occurrence of overweight and stunting within individuals in Ghana. This paper presents the burden, the individual-level, and contextual determinants of overweight with concurrent stunting among Ghanaian children.

**Methods:** This study analyzed data set of the fourth round of the Ghana Multiple Indicator Cluster Survey (MICS4). Bivariate analyses were used to describe selected characteristics of survey respondents and their children. Hierarchical modelling approach facilitated identification of significant distal, intermediate and proximal factors/determinants of concurrent stunting and overweight. Both crude and adjusted prevalence ratios via a multivariable Poisson regression model with their corresponding 95% Confidence Intervals (CI) are reported. Variables with  $p \leq 0.25$  at the bivariate level were included in the multivariable analysis. An alpha value of 5% was used to indicate significance.

**Results:** Of 7550 cases (children) analyzed, the prevalence of stunting was 27.5%; underweight was 17.3%; and wasting was 7.7%. The prevalence of overweight and concurrent overweight and stunting were respectively 2.4% and 1.2%. Children who belonged to the fourth wealth quintile, were more likely to be overweight and concurrently stunted as against children belonging to the poorest quintile (aPR = 1.010; 95% CI, 1.003–1.017). Compared to religious (Christians/Muslim/Traditionalist) household heads, children whose household heads did not belong to any religion had 2 times the rates of the Overweight with concurrent stunting (PR = 2.024; 95% CI, 1.016–4.034). Children with mothers aged 20–34 and 35–49 had an increased though insignificant prevalence ratio of association (aPR = 1.001; 95% CI, 0.994–1.005) and (aPR = 1.001; 95% CI, 0.998–1.012) respectively.

**Conclusion:** This analysis determined the prevalence of concurrent stunting and overweight among Ghanaian children to be 1.2%. Four contextual variables (breastfeeding status, religion, geographic region, and wealth index quintile) were associated with overweight with concurrent stunting. We conclude that, only contextual factors are predictive of DBM among children under five living in Ghana.

**Keywords:** Stunting, Overweight, Overweight with concurrent stunting, Undernutrition, Overnutrition and children under-five, Ghana

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## Background

Child growth is an important public health indicator for monitoring nutritional status and health in populations [1]. Information on undernutrition prevalence in children is a proximate indicator of the overall nutritional and food security conditions in a country [2]. Children at the start of their life have greater nutritional needs owing to the rapid pace of their growth [3]. It has been established that early malnutrition begins in utero during the early embryonic and fetal development stages, where the developing fetus solely depends on its genotype and the materno–fetal environment [4]. This period is characterised with increased energy demands to meet the metabolic demands of pregnancy [5]. Undernutrition and overnutrition, which we now know can originate from early childhood [4] can lead to the death of many young children [6] as well as onset of nutrition related illness or other complications later in life [1].

Although the prevalence of overnutrition in Ghana has not reached epidemic proportions [7] – in comparison with countries from the developed world, there is evidence of an alarming upward trend in many developing countries [8]. The change in Ghanaian lifestyles and consumption patterns are contributing factors to inadequate growth coupled with excess weight gain [9, 10]. The economic, demographic, environmental and cultural changes are known determinants of the changes in lifestyles and consumption patterns reported in other industrial countries with increased overnutrition rates [11]. Infections and social determinants are key determinants of undernutrition [12].

Overweight with concurrent stunting coexist at individual levels, national and community levels, and within households [13–20]. Concurrency of overweight and stunting has been found to exist in children in rural Mexico, Peru, Russia, Brazil, South Africa and China [21–23]. A key determinant is fetal undernutrition especially during the first thousand days of life [4]. Other distal level determinants are poor environmental conditions and overpopulation [24]. Double burden of malnutrition increases the risk of mortality, morbidity and poor cognitive development. Poor health and development in early life can limit the educational, social and economic achievements of individuals across their life span and increase the risk of poor adult health [25, 26]. The determinants, as well as the biochemical and environmental bases of the linkage between childhood nutritional stunting and various adverse outcomes have been explored. For instance, childhood nutritional stunting has been shown to be associated with impaired fat oxidation, a factor that predicts obesity in other at-risk populations [27]. In later years of life, stunting and overweight, directly or indirectly affects the child's growth, socially, emotionally, morally and academically [27]. In addition, birth interval, size at birth [28];

type of birth whether multiple or single births [29, 30]; ethnicity [31]; sex, type of residence and limited access to safe drinking water [32]; genetic factors, [31] among some others, were found to be determinants of stunting.

Determinants of overweight as reviewed from literature include; parental overweight [32, 33]; a male child with a young overweight mother [23]; age and household composition [34] occupation of the mother and mother's BMI [35]; socioeconomic class and ethnic variables [36] family size and income [37, 38].

The factors associated with concurrent stunting and overweight have been identified elsewhere and include maternal height, age, education, household size, and lower socioeconomic status [11, 21, 23, 39]; sex, age in months, urban–rural residence, geographic region, maternal education and household wealth [40]; rural or urban setting and sanitation, [23]. Put together, concurrency of stunting and overweight is influenced by socioeconomic, demographic, and environmental factors [28].

Ghana records significant numbers of both undernutrition and overnutrition [7]. Commonly referred to as the double or dual burden of malnutrition, the coexistence of contrasting forms of malnutrition is fast becoming major public health problem in both developed and developing country settings [7, 9, 41–44]. A country with high burdens of underweight, stunting, and overweight, is assumed to be in its stages of nutrition transition [41]. Children under five are most susceptible to this condition [39, 44]. Nationally representative Ghanaian surveys (DHS, MICS) report coexistence of the stunting and overweight in the Ghanaian community, but not within individuals. The current study aimed to assess the prevalence of overweight with concurrent stunting, and its individual and contextual determinants among Ghanaian children.

## Methods

### Design and study sites

The study was a secondary data analysis of nationally representative survey [7]. The current analysis assessed the prevalence of overweight with concurrent stunting among Ghanaian children under five and determined the individual and contextual determinants of overweight with concurrent stunting. The Ghana MICS collected data from all 10 regions in Ghana which included rural and urban settlements with randomly selected households.

### Study population, inclusion and exclusion criteria

This study made use of data collected from women (15–49 years) and children (0–5 years). The study's population was the MICS sample of selected households. The study made use of data obtained from households where children under five were identified. Data used in this analysis include; household data, birth history, women's data and

children's data obtained from their mothers or primary caretakers.

### Sample size and sampling

The study made use 7550 children for whom complete interview responses were obtained from their mothers or caregivers during the MISC4 survey. This study employed the sampling and sampling size procedures as explained in the Ghana MICS 2011 report.

The MICS4 sample survey used a random two-stage sample survey, (multi-stage, stratified cluster sampling approach). The first stage of the survey dealt with the selection of Primary Sampling Units (PSUs) from a sampling frame which was the list of the 2010 Ghana Population and Housing Census Enumeration areas (EAs). The 2010 Population and Housing census was used for the selection of clusters. Census EAs were defined as PSU. The second stage dealt with the selection of the Secondary Sampling Units (SSUs) which was the selection of households from each selected EA in first stage. PSUs were selected from each of the sampling strata using systematic Probability Proportional Sample (PPS) based on estimated sizes of the EA from the 2010 Population Census. Each region in Ghana, is made up of two strata: the urban and the rural areas. The total number of strata was therefore 20 for the whole country. Sample selection and estimation were conducted separately in each stratum. With the list of households from the 2010 Population Census, the total number of households in each selected cluster (Enumeration Area) was sequentially numbered from 1 to n at the Ghana Statistical Service; and then the selection of 15 households in each cluster was carried out using random systematic selection procedures. Households sample size calculation formula

$$n = \frac{4r(1-r)f(1+t)}{(0.12r)^2 hp} \quad n = 810$$

Where:

n = the minimum number of households to be interviewed (95% CI)

$r^2$  = 2006 MICS value for the indicator

r = expected rate for the indicator for 2011

f = design effect for the indicator in MICS 2006

t = non response rate for households in MICS 2006

h = average household size in 2006 MICS

p = proportion of children aged 12–23 months among the total population.

This result suggested that for each region taken as domain the household sub sample size was 810. Details can be found in the MICS 2011 report.

### Variables

This study assessed the prevalence and determinants of overweight with concurrent stunting among children under-five years. Guided by previous studies [6, 23, 40, 45–48], explanatory variables were evaluated using bivariate and regression analysis. The variables were grouped into factors such as; distal, intermediate and proximal following [49, 50].

Distal factors	Intermediate factors
Child's characteristics <ul style="list-style-type: none"> <li>• Sex of household head</li> <li>• Religion of household head</li> <li>• Ethnicity of household head</li> <li>• Maternal education</li> <li>• Wealth index quintile</li> <li>• Mosquito net utilization</li> </ul>	<ul style="list-style-type: none"> <li>• Sources of drinking water</li> <li>• Marital status</li> <li>• Maternal age at child birth</li> <li>• Type of birth</li> <li>• Size of child at birth</li> <li>• Birth order</li> <li>• Area of residence</li> <li>• Geographic zones</li> <li>• Three northern and non-northern regions</li> <li>• Child taken to a health facility during illness</li> <li>• Child ever received any vaccinations</li> <li>• Anemia status</li> </ul>
Proximal factor <ul style="list-style-type: none"> <li>• Breastfeeding status</li> <li>• Child with diarrhea</li> <li>• Child with cough</li> <li>• Child given Vitamin A dose within last 6 months</li> </ul>	Other Factors –NHIS status <ul style="list-style-type: none"> <li>• Age and Sex of child</li> </ul>

### Measurement of nutritional status

The nutritional status of the children were measured using HAZ, WAZ, WHZ and BMIZ with consultation to the new cut-offs based on the 2006 WHO growth standards. Children whose appropriate height, weight were not recorded and with HAZ below –6 or above +6; WAZ below –6 or above +5; WHZ below –5 or above +5 and BMIZ below –5 or above +5 were excluded from the analysis [44]. HAZ, WAZ, WHZ and BMIZ which were continuous variables were categorized into mildly, moderately, or severely stunted, underweight and wasted whereas BMIZ was categorized into overweight and obese.

A child was regarded as mildly stunted, underweight or wasted if HAZ, WAZ and WHZ were less than two standard deviation (–1.00SD to –1.99SD) from the median reference population. Consequently, children were categorized as moderately or severely stunted, underweight or wasted if HAZ, WAZ and WHZ were two (–2.00SD to –2.99SD) or above three (<–3.00SD) standard deviations from the median of the reference population. Conversely, a child was considered as overweight and obese if BMIZ was greater than two (> +2.00SD) standard deviations from the median of the reference population. For the purpose of this study both obese and overweight children were referred to as overweight. Children who were moderately and severely stunted, and wasted were computed into stunting (< –2.00SD) and wasting

(< -2.00S.D) variables. A child who is simultaneously overweight and stunted was considered as having BMIZ > +2.00 S.D. and HAZ below -2.00SD computed into a variable named concurrency. The stunting, overweight and concurrency variables were dichotomized into being overweight and concurrently stunted or not. Univariate analysis was used to generate descriptive tabulations for key variables assessed from the MICS dataset. The background and socio-demographic variables were grouped under the assessed characteristics. The sex specific prevalence nutritional status of children were computed.

### Statistical analysis

Statistical analyses of the MICS4 data set were performed using IBM SPSS Statistics for Windows version 20.0. Key variables identified in the data sets for this study's analysis were transformed into either categorical or dichotomized variables. Variables that were categorized included religion and ethnicity of the household head, sources of drinking water, size of child at birth, the ten regions of Ghana and children's hemoglobin level. Child anemia status was dichotomized into anemic or normal. Children were dichotomized into either having cough, diarrhea or not. Malaria rapid test results were also dichotomized into whether the child's test was positive or negative.

Both bivariate and multivariable approaches were used to obtain prevalence ratios (PR). This was implemented using a Poisson regression with a robust estimation of the variance to obtain prevalence ratios (PR) with a 95% confidence interval. The justification for fitting the Poisson model instead of the logistic regression model was due to the focus of the study (nutritional status of children under-five). The simple and multiple Poisson regression modeling approach produced unadjusted/crude and adjusted associations between each of the key outcome variable and selected characteristics. In the simple regression model, each of the selected characteristics were assessed independently with the outcome variable. The multiple Poisson regression model took into consideration the hierarchical nature of the risk factors. There is the likelihood of distal (socio-economic and other variables) factors affecting either directly or indirectly all the other potential risk factors except age and sex. This was followed by the intermediate factors and then the proximal factors.

The analysis were considered in three different ways. The first was the unadjusted prevalence ratios followed by adjustment at only factor level (where distal factors are adjusted for without including proximal or intermediate factors) and lastly the hierarchical adjustment. In the hierarchical adjusted approach, the first model (model-1) considered only age and sex of the child and model-2 contained model-1 with the distal factors adjusted

for. The other models were similarly obtained with the final model which contains all the factors and the other variables presented in Table 4. Significant relationships were denoted with an asterisk (\*). \*\*\* and \*\* denoted statistical significance at  $p < 0.001$  and  $< 0.01$ , while \* denoted statistical significance at  $p < 0.05$ . The multiple Poisson regression model was developed for selected characteristics that were significant at  $p < 0.25$  as well as those recommended by literature.

### Results

Tables 1, 2, 3, and 4 present the background characteristics, and nutrition status of children under 5 years, assembled under; distal, intermediate and proximal factors as well as the child's age and sex. A little over 50 % of the sampled children were males (51.1%) and were between 36 and 47 months of age (21.2%). Christian household heads constituted about 48%, followed by Muslims, (31.5%), Traditionalists (14.2%) and other religions (6.4%). Also, most of the household heads were from Ghanaian northern tribes (60.6%). About 63.5% of the sampled women were married. Mothers with no formal education constituted, 54.1% with the least being 7.2% having a secondary education and or higher. Most of the under-fives and their household heads lived in rural areas (72%) especially in the northern geographical zone (54.6%).

### Nutritional status of children

Out of the total number of 7550 children 97.2% were included in the stunting analysis. Similarly, 97.9, 97.8, 97.1 and 96.6% included in the underweight, wasting, BMI calculation and overweight with concurrent stunting analysis. Under-fives whose height, weight and age were correctly recorded were included in the analysis. About 30% of the Ghanaian children were malnourished. The most prevalent form of malnutrition was stunting (27.5%) followed by underweight, (17.3%) wasting (7.7%) and overweight and obesity (2.4%). Overall, the prevalence of overweight with concurrent stunting was 1.2%. Most of the children under five were mildly stunted, mildly underweight and mildly wasted. Comparatively more males than females were stunted, underweight, wasted, overweight and anaemic (Details are presented in Table 2).

### Predictors of overweight with concurrent stunting (focus on age, sex and the distal factors)

Tables 1, 2 and 3 present the simple and multiple Poisson regression modelling of overweight with concurrent stunting under the distal, intermediate and proximal factors. Included in these tables are the age and sex of the children that are not affected by either of these three factors. The selected characteristics are displayed together with their unadjusted prevalence ratios and factors specific adjusted measures of association. The

**Table 1** Sex specific nutritional status of children under 5 according to four anthropometric indices, height for age, weight for age, weight for height and Body Mass Index

Characteristics	Overall n (%)	Male n (%)	Female n (%)
<b>Stunting</b>			
Mildly stunted	2287 (31.1)	1144 (15.6)	1143 (15.6)
Moderately stunted	1355 (18.5)	740 (10.1)	615 (8.4)
Severely stunted	667 (9.1)	380 (5.2)	287 (3.9)
Stunting (below -2 SD)	2022 (27.5)	1120 (15.3)	902 (12.3)
Total	7342		
<b>Underweight</b>			
Mildly underweight	2348 (31.8)	1197 (16.2)	1151 (15.6)
Moderately underweight	973 (13.2)	528 (7.1)	445 (6.0)
Severely underweight	306 (4.1)	186 (2.5)	120 (1.6)
Underweight (below -2SD)	1279 (17.3)	714 (9.7)	565 (7.6)
Total	7395		
<b>Wasting</b>			
Mildly wasted	1547 (21.0)	787 (10.7)	760 (10.3)
Moderately wasted	448 (6.1)	270 (3.7)	178 (2.4)
Severely wasted	118 (1.6)	75 (1.0)	43 (0.6)
High weight for height	144 (2.0)	86 (1.2)	58 (0.8)
Wasting (below -2SD)	566 (7.7)	345 (4.7)	221 (3.0)
Total	7381		
<b>Body Mass Index</b>			
Overweight/obese (> +2SD)	178 (2.4)	103 (1.4)	75 (1.0)
Overweight	130 (1.8)	80 (1.1)	50 (0.7)
Obese	48 (0.7)	23 (0.3)	25 (0.3)
Total	7328		
<b>Concurrency</b>			
Total	88 (1.2)	51 (0.7)	37 (0.5)
<b>Anemia status</b>			
Normal	1535 (34.0)	710 (15.7)	825 (18.3)
Mild anemic	1036 (22.9)	526 (11.6)	510 (11.3)
Moderate anemic	1756 (38.9)	888 (19.7)	868 (19.2)
Severe anemic	190 (4.2)	127 (2.8)	63 (1.4)
Total	4517		

Mildly: z-score - 1.00SD to -1.99SD; moderately: z-scores -2.00SD to -2.99SD; severely: z-score less than 3.00SD; overweight: z-score + 2.00SD to 2.99SD and obese -z-score greater than 3.00SD. Normal-11 g/dl and above; mild anemia- 10 g/dl - 10.9 g/dl; moderate anemia-7 g/dl - 9.9 g/dl; severe anemia- less than 7 g/dl

hierarchical modelling of all the factors presented according to levels (from Model-1 to Model-4) are in Table 5.

The results of the Poisson regression model showed that the overall rates **overweight with concurrent stunting** with increasing age of a child was not statistically significant. However, children aged 11–23 months compared to 0–11 months were less likely to be concurrently stunted

with overweight (aPR = 0.990; 95% CI, 0.982–0.999). Although not reaching statistical significance, the prevalence ratio of overweight with concurrent stunting was lower among girls compared to their male counterparts (PR = 0.754; 95% CI, 0.495–1.149). After adjusting for potential confounders at factor-specific and the overall model adjustment levels, female children were more likely to be concurrently stunted and overweight, (aPR = 1.003; 95% CI, 0.998–1.007), although this was not statistically significant. Also no significant changes were observed for increasing age at the model specific adjusted rate ratios. Children whose household heads did not belong to any religion had more than twice the rates of those from the Christian religion (PR = 2.024, 95% CI, 1.016, 4.034) and this was statistically significant. Though Traditional and the Islamic religions were not statistically significant, both had higher rates of overweight and concurrent stunting than their Christian religious colleagues Table 1. After factor-specific adjustments of prevalence ratios, not belonging to any religion was associated with reduced likelihood to experience concurrent stunting and overweight (aPR = 0.987; 95% CI, 0.974–1.002). Of note, this was statistically significant after adjustments (see adjusted prevalence ratio of 1.020 with 95% confidence interval of (1.002–1.038) under Model-4 in Table 5). Compared to the poorest quintile, children belonging to the fourth index quintile had a significantly increased rates of overweight with concurrent stunting (aPR = 1.010; 95% CI, 1.010–1.017).

#### Predictors of overweight with concurrent stunting with Intermediate factors

Although not statistically significant, children sampled from the rural areas were more likely to be concurrently stunted and overweight compared to those from the urban areas (PR = 1.329; 95% CI, 0.810–2.183) Table 3. Also, children from the three regions of the North were about 16% less likely to be concurrently stunted and overweight against children from the Southern part. This reduced to about 0.4% after adjusting for other covariates. There was no statistically significant difference between mothers who were below the age of 20 and 20–34 (PR = 1.002; 95% CI, 0.995–1.009) and 35–49 (PR = 1.002; 95% CI, 0.993–1.012). Children with mothers aged 20–34 and 35–49 compared to those less than 20 years had more rates (aPR = 1.001; 95% CI, 0.994–1.005 and aPR = 1.001; 95% CI, 0.998–1.012) respectively.

#### Predictors of overweight with concurrent stunting with proximal factors

There were no significant effect of the proximal factors on concurrent stunting and overweight at the 5% level

**Table 2** Distribution of overweight with concurrent stunting according to the distal factors as well as the child's age and sex with their corresponding unadjusted and adjusted prevalence ratios

Variables	Level	Frequency (%)	Crude PR (95% CI)	Adjusted PR (95% CI)
Child's age in months	0–11	1512 (20.03)	Ref	Ref
	12–23	1451 (19.22)	0.990 (0.982–0.999)*	0.990 (0.982–0.999)*
	24–35	1518 (20.11)	0.994 (0.986–1.002)	0.994 (0.986–1.002)
	36–47	1599 (21.18)	0.997 (0.989–1.004)	0.997 (0.989–1.004)
	48–59	1470 (19.47)	0.960 (0.993–1.007)	1.000 (0.993–1.007)
Sex of child	Male	3859 (51.11)	Ref	Ref
	Female	3691 (48.89)	0.754 (0.495–1.149)	1.003 (0.998–1.009)
Distal Factors				
Sex of household head	Male	5012 (67.84)	Ref	Ref
	Female	2376 (32.16)	1.000 (0.996–1.006)	1.000 (0.995–1.006)
Religion of household head	Christian	3623 (47.99)	Ref	Ref
	Muslim	2376 (31.47)	1.084 (0.661–1.770)	0.997 (0.990–1.004)
	Traditional/ Spiritualist	1070 (14.17)	1.147 (0.613–2.145)	0.997 (0.989–1.006)
	Other religion/ No Religion	481 (6.37)	2.024 (1.016–4.034)*	0.987 (0.974–1.002)
Ethnicity of household head	Akan	1889 (25.02)	Ref	Ref
	Ga/Dangme	281 (3.72)	1.004 (0.990–1.018)	1.002 (0.988–1.012)
	Ewe	587 (7.77)	1.006 (0.991–1.016)	1.008 (0.998–1.017)
	Northern tribes	4572 (60.56)	1.004 (0.997–1.010)	1.008 (1.000–1.016)*
	Non-Ghanaian/ others	221 (2.93)	0.995 (0.976–1.015)	0.997 (0.975–1.020)
Maternal education	None	4081 (54.05)	Ref	Ref
	Primary	1363 (18.05)	1.356 (0.812–2.264)	0.996 (0.990–1.004)
	Middle/JSS	1565 (20.73)	0.956 (0.550–1.663)	1.001 (0.993–1.010)
	Secondary +	541 (7.17)	0.663 (0.240–1.834)	1.007 (0.995–1.019)
Wealth index quintile	Poorest	3528 (46.73)	Ref	Ref
	Second	1499 (19.85)	0.853 (0.493–1.491)	1.005 (0.998–1.012)
	Middle	1045 (13.84)	0.945 (0.513–1.743)	1.004 (0.995–1.012)
	Fourth	836 (11.07)	0.364 (0.131–1.008)	1.010 (1.003–1.017)*
	Richest	642 (8.50)	0.970 (0.460–2.044)	1.000 (0.984–1.014)
Mosquito net utilization				
Mother and child slept under mosquito net last night	Yes	3268 (43.28)	Ref	Ref
	No	4282 (56.72)	0.801 (0.528–1.213)	1.003 (0.942–1.068)

\* denotes statistical significance at  $p$  value  $< 0.05$

Christian comprise; Catholic, Pentecost, Deeper life, Jehovah witness, SDA and other Christian religions; Northern tribes - Comprise Guan, Gruma, Mole Dagbaani, Grusi and Mande

of significance. It was observed that breastfed children were 77% less likely to experience any concurrent stunting and overweight as against those who were not breastfed (PR = 0.231; 95% CI, 0.075–0.710). After adjusting for all the other variables, this group was 1.028 times more likely to be concurrently stunted and overweight than those not breastfed. Children with diarrhoea were 7% more likely to be classified under concurrent stunting and overweight than those without (PR = 1.069; 95% CI, 0.606–1.886 and aPR = 1.027; 95% CI, 0.986, 1.069), though both were statistically not significant.

## Discussion

### Prevalence of overweight with concurrent stunting

Concurrent stunting and overweight is a manifestation of the overweight with concurrent stunting in individuals. Previous analysis of the Ghana MICS4 data sets and other studies indicated the coexistence of overweight and stunting occurring at the national level [7, 41]. Similarly other previous studies from non-Ghanaian settings had showed the co-existence of overweight with concurrent stunting at the household and individual levels [16, 18, 21, 23, 51, 52]. Overall, 1.2% of Ghanaian children

**Table 3** Distribution of overweight with concurrent stunting according to the intermediate factors with their corresponding unadjusted and adjusted prevalence ratios

Variables	Level	Frequency (%)	Crude PR (95% CI)	Adjusted PR (95% CI)
Intermediate factors				
Sources of drinking water	Pipe water	2538 (34.35)	Ref	Ref
	Tube Well, Borehole, Tanker	2308 (31.24)	1.002 (0.996–1.008)	0.994 (0.986–1.002)
	River, Spring and other water bodies	946 (12.80)	0.996 (0.987–1.005)	1.001 (0.997–1.005)
	Bottled Water, Sachet Water	1596 (21.60)	1.003 (0.997–1.010)	0.995 (0.986–1.003)
Marital status	Currently married	4654 (63.51)	Ref	Ref
	Formerly married	587 (8.01)	1.003 (0.994–1.011)	0.989 (0.957–1.022)
	Never married	2087 (28.48)	0.996 (0.990–0.998)*	0.992 (0.981–0.997)*
Maternal age at child birth	Less than 20	1400 (18.54)	Ref	Ref
	20–34	5226 (69.22)	1.002 (0.995–1.009)	1.001 (0.994–1.005)
	35–49	924 (12.24)	1.002 (0.993–1.012)	1.001 (0.998–1.012)
Type of birth	Twin	296 (3.92)	Ref	Ref
	Single	7254 (96.68)	1.000 (0.992–1.026)	1.009 (0.984–1.034)
Size of child at birth	Large	825 (43.13)	Ref	Ref
	Average	870 (45.48)	1.004 (0.998–1.010)	1.004 (0.997–1.010)
	Small	218 (11.40)	1.001 (0.991–1.012)	1.001 (0.990–1.012)
Birth order	1	2127 (28.17)	Ref	Ref
	2–3	2973 (39.83)	1.000 (0.993–1.006)	0.997 (0.991–1.002)
	4–6	1919 (25.42)	1.002 (0.996–1.010)	0.995 (0.987–1.003)
	7 +	531 (7.03)	1.001 (0.991–1.012)	1.000 (0.996–1.014)
Area of residence	Urban	2117 (28.04)	Ref	Ref
	Rural	5433 (71.96)	1.329 (0.810–2.183)	1.001 (0.997–1.034)
Geographic zones	Coastal/southern Zone	1806 (23.92)	Ref	Ref
	Middle zone	1624 (21.51)	0.872 (0.480–1.581)	1.011 (1.000–1.014)*
	Northern zone	4120 (54.57)	0.817 (0.500–1.336)	1.012 (0.998–1.026)
Three northern and non-northern regions	All but three northern regions	2551 (33.79)	Ref	Ref
	Three northern regions	4999 (66.21)	0.848 (0.552 – 1.302)	0.996 (0.986 – 1.001)

under five were concurrently overweight and stunted. This prevalence determined by the current study was low compared to previous studies that assessed DBM in children under five living in developing countries [21–23, 41]. Adel et al. who conducted a population based survey on the nutritional status of under-fives in Libya reported the prevalence of DBM to be 7%. Popkin, et al. [22] who similarly examined the relationship between stunting and overweight status for Russian, Brazilian, South African and Chinese children reported a significant association between stunting and overweight status in children of all countries, which showed an income adjusted risk ratios of being overweight for a stunted child as being ranged from 1.7 to 7.8. Fernald et al. [23] reported the prevalence of overweight with concurrent stunting among rural low-income Mexican pre-school children was approximately 5% in non- indigenous children, and

over 10% in indigenous children. A nationwide study conducted by Masibo et al., [53] among Kenyan children under-fives revealed an evident emergence DBM demonstrated by stunted and underweight children whose mothers are overweight. Similarly, Provo's [18] study using Demographic Health Survey (DHS) data from Eastern, Middle, Southern, and Western Africa also revealed high prevalence of Double Burden of Malnutrition (DBM).

According to Kimani-murage et al., [17], the DBM is evident in societies undergoing nutrition transition especially in LMICs. This compares with Ghana since its declaration of being a middle income country [54]. Nutrition transition characterizes the shift in disease patterns towards nutrition-related NCD's, which is associated with changes in behaviors, lifestyles, diets, physical inactivity, smoking and alcohol consumption [55].

**Table 4** Distribution of overweight with concurrent stunting according to their proximal factors with their corresponding unadjusted and adjusted prevalence ratios

Variables	Level	Frequency (%)	Crude PR (95% CI)	Adjusted PR (95% CI)
Proximal factors				
Breastfeeding status				
Child ever been breastfed	Yes	7484 (99.17)	0.231 (0.075–0.710)	1.028 (0.956–1.105)
	No	63 (0.83)	Ref	Ref
Child health status				
Child with diarrhoea	Yes	1126 (14.92)	1.069 (0.606–1.886)	1.027 (0.986–1.069)
	No	6422 (85.08)	Ref	Ref
Child with cough	Yes	1672 (22.15)	0.717 (0.412–1.246)	1.048 (0.993–1.106)
	No	5876 (77.85)	Ref	Ref
Child given Vitamin A dose within last 6 months	Yes	2269 (30.65)	0.925 (0.591–1.447)	
	No	5134 (69.35)	Ref	Ref
Child taken to a health facility during illness	Yes	893 (78.06)	1.669 (0.202–13.809)	1.001 (0.928–1.092)
	No	251 (21.94)	Ref	Ref
Child ever received any vaccinations	Yes	1211 (90.31)	0.517 (0.153–1.749)	0.961 (0.912–1.012)
	No	130 (9.69)	Ref	Ref
Anaemia status				
	Normal	1535 (33.98)	Ref	Ref
	Anaemia	2882 (66.02)	0.920 (0.518–1.632)	1.025 (0.931–1.128)

### Individual and contextual determinants of overweight with concurrent stunting

#### Individual determinants

Previous studies have reported that the sex of a child is a significant determinant of DBM. Our analysis revealed that female children tended to experience more DBM than their male counterparts although this was not statistically significant after adjusting for various covariates – as in Masibo and Makoka [53] and Provo [18]. Children between 12 and 23 months and 24–35 months recorded the highest prevalence of DBM with children below one year recording the least (0.1%). In general, there was a non-significant reduction in prevalence ratios as ages in months increased. Kroker-lobos et al. had previously reported similarly observed data [56].

The current analysis identified a number of contextual predictors of concurrent overweight and stunting in Ghanaian children. The significantly associated factors are wealth index quintile, belonging to either no religion or other religions, and geographic zones. Compared to the poorest wealth index quintile, children belonging to the fourth index quintile had a significantly decreased rates of concurrent overweight and stunting but after adjusting for factor specific and the hierarchical levels an increased rates of concurrent overweight and stunting was observed. This study agreed with Fernald [23] conclusion that children living in lower SES were more exposed to the occurrence of concurrent overweight and stunting. Mothers who were educated at the secondary level or higher had a higher increased rates of concurrent

overweight and stunting though insignificant. The prevalence of the concurrent overweight and stunting could be associated to lower educational levels and socioeconomic status of women, which are determinants of poor nutrition practices in developing countries where children under five are mostly affected [24]. Children belonging to mothers between 25 and 34 and 35–49 years were 0.1% more likely when compared to 15–19 years to be overweight and concurrently stunted. This could imply that nutrients needed by adolescent mothers, for optimum growth and development are been competed for especially during pregnancy and lactation. This competition for nutrients especially iron could predispose the adolescent mother to micronutrient deficiency. This micronutrient deficiency affects uterine development and further result in the birth of a low weight baby who may be predisposed to chronic illness and may eventually lead to the onset of DBM. Additionally, Adair et al., indicated that, “Low Birth weight (LBW) infants tend to have greater adult lean mass and human capital when they experience rapid weight gains still in the first one thousand days of life.” The same study associated weight gains in later life to adverse cardiovascular consequences [57].

Rural children were 33% (unadjusted) and 1% (adjusted) more more likely to experience concurrent stunting and overweight compared to their urban counterparts. This compares favorably with the findings of Oddo et al., (2012) where DBM was not exclusive to urban areas. Their recommendation that future policies and interventions should address DBM in both rural

**Table 5** Distribution of overweight with concurrent stunting according to the characteristics with their corresponding hierarchical model adjusted prevalence ratios

Variables	Level	Model 1			Model 2			Model 3			Model 4		
		Adjusted PR (95% CI)	p - value	Adjusted PR (95% CI)	p-value	p-value							
Child's age in months	0–11	Ref	0.495	Ref	0.461	Ref	0.474	Ref	0.474	Ref	0.155		
	12–23	0.990 (0.982–0.999)		0.991 (0.982–1.000)		0.991 (0.982–0.999)		0.993 (0.975–1.011)					
	24–35	0.994 (0.986–1.002)		0.994 (0.967–1.002)		0.994 (0.986–1.002)		0.994 (0.948–1.000)					
	36–47	0.997 (0.989–1.004)		0.997 (0.990–1.004)		0.997 (0.989–1.004)		1.000 (0.987–1.013)					
	48–59	1.000 (0.993–1.007)		1.000 (0.993–1.007)		1.000 (0.993–1.007)		1.001 (0.985–1.018)					
Sex of child	Male		0.186		0.186		0.188		0.188		0.951		
	Female	1.003 (0.998–1.009)		1.004 (0.999–1.009)		1.004 (0.999–1.009)		1.003 (0.987–1.020)					
Religion of household head	Christian			Ref	0.147	Ref	0.129	Ref	0.129	Ref	0.991		
	Muslim			0.997 (0.990–1.004)		0.997 (0.989–1.004)		1.017 (0.989–1.045)					
	Traditional/ Spiritualist			0.998 (0.990–1.007)		0.998 (0.989–1.007)		0.981 (0.933–1.032)					
	Other religion/ No Religion			0.989 (0.975–1.003)		0.989 (0.975–1.003)		1.020 (1.002–1.038)					
Ethnicity of household head	Akan			Ref	0.073	Ref	0.350	Ref	0.350	Ref	0.947		
	Ga/Dangme			1.003 (0.989–1.018)		1.004 (0.989–1.019)		1.013 (0.996–1.030)					
	Ewe			1.009 (0.999–1.018)		1.009 (0.998–1.020)		1.023 (1.000–1.046)					
	Northern tribes			1.008 (1.000–1.016)		1.006 (0.996–1.017)		1.001 (0.970–1.032)					
	Non-Ghanaian/ others			0.999 (0.977–1.021)		0.998 (0.977–1.020)		0.976 (0.911–1.046)					
Maternal education	None			Ref	0.969	Ref	0.944	Ref	0.944	Ref	0.430		
	Primary			0.995 (0.988–1.003)		0.996 (0.988–1.003)		0.986 (0.963–1.011)					
	Middle/JSS			1.000 (0.992–1.009)		1.000 (0.992–1.009)		1.016 (0.992–1.039)					
	Secondary +			1.003 (0.990–1.016)		1.003 (0.990–1.016)		1.022 (0.982–1.063)					
Wealth index quintile	Poorest			Ref	0.205	Ref	0.335	Ref	0.335	Ref	0.335		
	Second			1.004 (0.997–1.012)		1.005 (0.997–1.012)		0.991 (0.967–1.015)					
	Middle			1.004 (0.995–1.012)		1.004 (0.993–1.015)		0.991 (0.969–1.012)					
	Fourth			1.011 (1.004–1.019)		1.011 (1.001–1.021)		0.997 (0.972–1.023)					
	Richest			1.001 (0.986–1.016)		1.001 (0.984–1.019)		0.954 (0.900–1.013)					
Maternal age at child birth	Less than 20					Ref	0.633	Ref	0.633	Ref	0.873		
	20–34					1.001 (0.995–1.008)		0.989 (0.969–1.001)					
	35–49					1.002 (0.993–1.011)		1.000 (0.981–1.019)					
Area of residence	Urban					Ref	0.848	Ref	0.848	Ref	0.855		
	Rural					0.999 (0.991–1.007)		1.003 (0.987–1.020)					

**Table 5** Distribution of overweight with concurrent stunting according to the characteristics with their corresponding hierarchical model adjusted prevalence ratios (Continued)

Geographic zones	Coastal/southern Zone	Ref	0.544	Ref	0.707
	Middle zone	0.999 (0.989–1.010)		0.987 (0.967–1.008)	
	Northern zone	1.000 (0.988–1.012)		0.989 (0.957–1.022)	
Three northern and non-northern regions	All but three northern regions	Ref	0.885	Ref	0.564
	Three northern regions	1.003 (0.990–1.016)		1.000 (0.967–1.034)	
Breastfeeding status					
	Child ever been breastfed	Yes		0.995 (0.984–1.006)	0.034
		No		Ref	
Child health status					
	Child with diarrhoea	Yes		1.019 (1.006–1.032)	0.04
		No		Ref	
	Child with cough	Yes		1.003 (0.985–1.021)	0.807
		No		Ref	
	Child ever received any vaccinations	Yes		0.997 (0.960–0.995)	0.010
		No		Ref	
Malaria rapid test outcome					
	Positives			Ref	0.299
	Negative			1.012 (0.994–1.030)	

and urban developing country settings are relevant in our context.

### Study strength and weakness

A major strength of this study, is the analytic method used. The Ghana MICS stopped at the univariate level but this study went beyond just looking at Univariate and explored both bivariate and multivariable analysis. The Poisson regression model was used due to its advantage over the logistic model to determine associations between the outcome (dichotomous) and the predictor variables. An important limitation of this study is that strong conclusions could not be drawn with respect to the causes of DBM. This is because the original survey [7], from which our paper metamorphosed did not assess certain key variables that are potentially linked to the nutritional status of the under-five children. Also due to the cross-sectional design of the survey, no causal linkages can be inferred.

### Conclusions

This analysis determined the prevalence of concurrent stunting and overweight among Ghanaian children to be 1.2%. Four contextual variables (breastfeeding status, religion, geographic region, and wealth index quintile) were associated with overweight with concurrent stunting. After factor-specific adjustments of prevalence ratios, not belonging to any religion was associated with a marginally reduced likelihood of experiencing concurrent stunting and overweight. Compared to the poorest quintile, children belonging to the fourth wealth quintile had significantly increased rates of overweight with concurrent stunting. Intermediate level predictor of overweight with concurrent stunting was geographic region. Children from the three northern regions were about 16% less likely to be concurrently stunted and overweight against children from the Southern part. This was, however, significantly reduced after adjusting for other covariates. With the exception of breastfeeding, the current analysis did not reveal significant proximal level predictors of overweight with concurrent stunting. Breastfed children were 77% less likely to experience any concurrent stunting and overweight compared to those who were not breastfed. We conclude that, only contextual factors are predictive of DBM among children under five living in Ghana.

### Abbreviations

BMI: Body mass index; BMIZ: Body mass index Z – scores; CI: Confidence interval; DBM: Double/ dual burden of malnutrition; DHS: Ghana demographic health survey; GSS: Ghana statistical service; HAZ: Height for age Z – score; JSS: Junior High School; LMIC's: Low and middle income countries; MICS: Multiple indicator cluster survey; MICS4: Fourth round of the multiple indicator cluster survey; NCD: Non-Communicable diseases; NHIS: National health insurance scheme; PPS: Probability proportional sample; PR: Prevalence ratio; PSUs: Primary sampling units; SES: Socioeconomic status; SSUs: Secondary sampling units; WAZ: Weight for Age Z – score; WHO: World Health Organization

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### Availability of data and materials

Our analysis is done of a publicly available and accessible nationally representative survey (Ghana MICS). We would like to emphasize that we do not have special access privileges to these data and that interested researchers may apply to access the data at this site <http://mics.unicef.org/surveys>.

### Authors' contributions

AKL conceived the idea and discussed with BKA, and CG for inputs. BKA put up the framework. AKL developed the initial analysis plan and guided BKA in the data analysis. BKA, and AKL drafted different sections of the manuscript. CG re-analysed the data and wrote the results section in response to important queries from reviewers. CG provided inputs in the revision of the manuscript. All authors read and approved the final version of the manuscript.

### Ethics approval and consent to participate

Ethical approval for the Multiple Indicator Cluster Survey (MICS) was obtained from the Ghana Health Service. The current paper made use of the secondary data from the MICS. The data sets, is publicly available. Request for the use of the datasets was granted by the United Nations Children's Emergency Fund.

### Consent for publication

Not applicable.

### Competing interests

The authors declare that they have no competing interests.

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### References

1. Md O, Blössner M. The World Health Organization global database on child growth and malnutrition : methodology and applications. *Int J Epidemiol*. 2003;32:518–26.
2. Nube M. Relationships between undernutrition prevalence among children and adult women at national and subnational level. *Eur J Clin Nutr*. 2005;59:1112–20.
3. Cristina V, Vieira R. Stunting : its relation to overweight, global or localized adiposity and risk factors for chronic non-communicable diseases Deficit estatural : relações com sobrepeso, adiposidade global ou localizada e fatores de risco para doenças crônicas não- transm. *Rev Bras Saude Mater Infant*. 2007;7(4):365–72.
4. Langley-Evans SC. Nutritional programming of disease: Unravelling the mechanism. *J Anat*. 2009;215:36–51.
5. Brett K, Ferraro Z, Yockell-Lelievre J, Gruslin A, Adamo K: Maternal–fetal nutrient transport in pregnancy pathologies: the role of the placenta. 2014;15:16153–16185.
6. Jesus GMD, Vieira GO, Vieira TO, Martins CDC, Mendes CM, Castelhão ES. Determinants of overweight in children under 4 years of age. *Jornal de Pediatria*. 2010;86(4):311–6.
7. Ghana Statistical S: Multiple indicator cluster survey with an enhanced malaria module and biomarker. 2011.
8. Appiah CA, Steiner-asiedu M, Otoo GE. Predictors of overweight / obesity in Urban Ghanaian Women. *Int J Clin Nutr*. 2014;2(3):60–8.

9. Jehn M, Brewis A. Economics and human biology paradoxical malnutrition in mother – child pairs : untangling the phenomenon of over- and under-nutrition in underdeveloped economies. *Econ Hum Biol.* 2009;7:28–35.
10. Ageyi-Mensah S, de-Graft Aikins A. Epidemiological transition and the double burden of disease in Accra, Ghana. *J Urban Health.* 2010;87(5):879–97.
11. Mamabolo RL, Alberts MSNP, Delemarre-van de Waal HA, Levitt NS. Prevalence and determinants of stunting and overweight in 3-year-old black South African children residing in the Central Region of Limpopo Province, South Africa. *Public Health Nutr.* 2005;8(5):501–8.
12. Frempong GA: Perceived body weight and actual Body Mass Index (BMI) Among urban poor communities in Accra, Ghana. 2013.
13. Bourne LT, Langenhoven ML, Steyn K, Jooste PL, Laubscher JA, Bourne DE: Nutritional status of 3–6 year-old African children in the Cape peninsula. 1994;71:695–702.
14. Doak CM, Adair LS, Bentley M, Monteiro C, Popkin BM. The dual burden household and the nutrition transition paradox. *Int J Obes.* 2005;29(1):129–36.
15. Florêncio TM, Ferreira HS, de França AP, Cavalcante JC, Sawayá AL. Obesity and undernutrition in a very-low-income population in the city of Maceió, northeastern Brazil. *Br J Nutr.* 2001;86(2):277–84.
16. Garrett J, Ruel MT. The coexistence of child undernutrition and maternal overweight: prevalence, hypotheses, and programme and policy implications. *Maternal & child nutrition.* 2005;1(3):185–96.
17. Kimani-murage EW, Kahn K, Pettifor JM, Tollman SM, Dunger DB, Gómez-olivé XF, Norris SA. The prevalence of stunting, overweight and obesity, and metabolic disease risk in rural South African children. *BMC Public Health.* 2010;10:1–13.
18. Provo AM. Towards Sustainable Nutrition for All Tackling the double burden of malnutrition in Africa. *Sight Life.* 2013;27(3):40–8.
19. Steyn K, Bourne L, Jooste P, Fourie JM, Rossouw K, Lombard C. Anthropometric profile of a black population of the Cape Peninsula in South Africa. *East African Med J.* 1998;75(1):35–40.
20. Wibowo Y, Sutrisna B, Hardinsyah H, Djuwita R, Korib MM, Syafiq A, Tilden A, Najib M. Relationship between intra-household food distribution and coexistence of dual forms of malnutrition. *Nutr Res Pract.* 2015;9(2):174.
21. Urke HB, Mittelmark MB, Valdivia M. Trends in stunting and overweight in Peruvian pre-schoolers from 1991 to 2011 : findings from the Demographic and Health Surveys. *Public Health Nutr.* 2014;17(11):2407–18.
22. Popkin BM, Richards MK, Montiero CA. Stunting is associated with overweight in children of four nations that are undergoing the nutrition transition. *J Nutr.* 1996;126(12):3009.
23. Fernald LC, Neufeld LM. Overweight with concurrent stunting in very young children from rural Mexico: prevalence and associated factors. *Eur J Clin Nutr.* 2007;61(5):623–32.
24. Bain LE, Awah PK, Geraldine N, Kindong NP, Sigal Y, Bernard N, Tanjeko AT. Malnutrition in Sub-Saharan Africa: burden, causes and prospects. *Pan Afr Med J.* 2013;15:120.
25. de Onis M, Blössner M, Borghi E, Morris R, Frongillo EA. Methodology for estimating regional and global trends of child malnutrition. *Int J Epidemiol.* 2004;33(6):1260–70.
26. De Haas H. Migration and development: a theoretical perspective. *Int Migr Rev.* 2008;44:227–64.
27. Paulo S, Hoffman DJ, Sawayá AL, Verreschi I, Tucker KL, Roberts SB. Why are nutritionally stunted children at increased risk of obesity ? Studies of metabolic rate and fat oxidation in shantytown children. *Am J Clin Nutr.* 2000;70:2–7.
28. Keino S, Plasqui G, Etyang G, van den Borne B. Determinants of stunting and overweight among young children and adolescents in sub-Saharan Africa. *Food Nutr Bull.* 2014;35(2):167–78.
29. Bhandari TR, Chhetri M. Nutritional status of under five year children and factors associated: a study in Kapilvastu District, Nepal. *J Nutr Health Food Sci.* 2011:1–6.
30. Hong R, Banta JE, Betancourt JA. Relationship between household wealth inequality and chronic childhood under-nutrition in Bangladesh. *Int J Equity Health.* 2006;5:15.
31. Shamah-levy T, Nasu LC, Moreno-macias H, Monterrubio-flores E, Avila-arcos MA. maternal characteristics determine stunting in children of less than five years of age results from a national probabilistic survey. *Clin Med.* 2008;1:43–52.
32. Strauss RS, Knight J. Influence of the home environment on the development of obesity in children. *J Am Acad Pediatr.* 1999;103(e85):1–8.
33. Danielzik S, Czerwinski-Mast M, Langnäse K, Dilba B, Müller MJ. Parental overweight, socioeconomic status and high birth weight are the major determinants of overweight and obesity in 5–7 y-old children: baseline data of the Kiel Obesity Prevention Study (KOPS). *Int J Obes Relat Metab Disord.* 2004;28(11):1494–502.
34. Mo-suwan L, Tongkumchum P, Puetpaiboon A. Determinants of overweight tracking from childhood to adolescence: a 5 y follow-up study of Hat Yai schoolchildren. *Int J Obes Relat Metab Disord.* 2000;24(12):1642–7.
35. Crepinsek B. Maternal employment and children's nutrition. food assistance & nutrition research program, vol. 1; 2004.
36. Dwyer JT, Feldman JJ, Mayer J. The social psychology of dieting. *J Health Soc Behav.* 2014;11(4):269–87.
37. Gonzalez-Casanova I, Sarmiento OL, Pratt M, Gazmararian JA, Martorell R, Cunningham SA, Stein A. Predictors of overweight and obesity among Colombian children and adolescents. *Ctr Dis Control Prev.* 2005;2014:1–12.
38. Kruger R, Kruger HS, Macintyre UE. The determinants of overweight and obesity among 10- to 15-year-old schoolchildren in the North West Province, South Africa - the THUSA BANA (Transition and Health during Urbanisation of South Africans; BANA, children) study. *Public Health Nutr.* 2006;9(3):351–8.
39. Steyn NP, Ph D, Labadarios D, Ch B, Maunder E, Nel J, Lombard C, Consumption F. Secondary anthropometric data analysis of the national food consumption survey in South Africa : the double burden. *Nutr J.* 2005;21:4–13.
40. Corvalán C, Gregory CO, Ramirez-Zea M, Martorell R, Stein AD. Size at birth, infant, early and later childhood growth and adult body composition: a prospective study in a stunted population. *Int J Epidemiol.* 2007;36(3):550–7.
41. Adel ET, Marie-Françoise RC, Salaheddin MM, Najeeb E, Abdel Monem A, Ibrahim B, Lenoir G. nutritional status of under-five children in Libya: a national population-based survey Libyan J Med, AOP : 071006. *Libyan J Med.* 1995:13–9.
42. Corsi DJ, Finlay JE, Subramanian S. Global burden of double malnutrition: has anyone seen it? *PLoS One.* 2011;6(9):e25120.
43. Shrimpton RRC. The Double Burden of Malnutrition: A Review of Global Evidence. World Bank; 2012. Accessed from <https://doi.org/10.1596/27417>. Accessed 12 Oct 2016.
44. Tzioumis E, Adair LS. Childhood dual burden of under- and overnutrition in low- and middle-income countries: a critical review. *Food Nutr Bull.* 2014; 35(2):230–43.
45. Adekanmbi VT, Kayode GA, Uthman OA. Individual and contextual factors associated with childhood stunting in Nigeria: a multilevel analysis. *Matern Child Nutr.* 2013;9:244–59.
46. Boyce SP, Walters T, Nyaku A: Contextual analysis of undernutrition outcomes and anaemia: Ghana. 2014: 4-5.
47. Galiano LP, Abril FM, Ernert A, Bau AM. The double burden of malnutrition and its risk factors in school children in Tunja. *Archivos latinoamericanos de nutrición.* 2012;62(2):119.
48. Wondimagedn ZT. Magnitude and determinants of stunting among children in Africa : a systematic review. *Curr Res Nutr Food Sci.* 2014;2(2):88–93.
49. Hien NN, Hoa NN. Nutritional status and determinants of malnutrition in children under three years of age in Nghean, Vietnam. *Pak J Nutr.* 2009; 8(7):958–64.
50. Victora CG, Huttly SR, Fuchs SC, Olinto M. The role of conceptual frameworks in epidemiological analysis: a hierarchical approach. *Int J Epidemiol.* 1997;26(1):224–7.
51. Rivera JA, Pedraza LS, Martorell R, Gil A. Double A: The complexity of the double burden of malnutrition : new evidence from Latin America Burden of Malnutrition Research Group Center for Nutrition and Health Research, National Institute of Public Health, Cuernavaca, Mexico Department of Biochemistry and. 2014:1–2.
52. Said-Mohamed R, Alliot X, Sobgui M, Pasquet P. Determinants of overweight associated with stunting in preschool children of Yaounde, Cameroon. *Ann Hum Biol.* 2009;36(2):146–61.
53. Masibo PK, Makoka D. Trends and determinants of undernutrition among young Kenyan children: Kenya Demographic and Health Survey; 1993, 1998, 2003 and 2008–2009. *Public Health Nutr.* 2012;15(09):1715–27.
54. Duffour K: Ghana now a lower middle income country. 2011.
55. Amuna P, Zotor FB. Epidemiological and nutrition transition in developing countries: impact on human health and development. *Proc Nutr Soc.* 2008;67(01):82–90.
56. Kroker-lobos MF, Pedroza-tob A, Pedraza LS, Rivera JA. The double burden of undernutrition and excess body weight in Mexico. *Am J Clin Nutr.* 2014;100(1):1652–8.
57. Adair LS, Guilkey DK. Age-specific determinants of stunting in Filipino children. *J Nutr.* 1997;127:314–20.