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Double burden of malnutrition among women in sub-Saharan Africa: A cross-country Analysis

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Abstract

Objective: To investigate the correlates of the double burden of malnutrition (DBM) among women in five sub-Saharan African countries

Design: Secondary analysis of Demographic and Health Surveys (DHS). The outcome variable was body mass index (BMI), a measure of DBM. The BMI was classified into underweight (BMI<18.50 kg/m^2), normal weight (18.50-24.99 kg/m^2), overweight (25.0-29.9 kg/m^2) and obese (≥ 30.0 kg/m^2).

Settings: Ghana, Nigeria, Kenya, Mozambique and Democratic Republic of Congo (DRC).

Subjects: Women aged 15-49 years (*n* 64,698).

Results: Compared with normal weight women, number of years of formal education was associated with the likelihood of being overweight and obese in Ghana, Mozambique and Nigeria, while associated with the likelihood of being underweight in Kenya and Nigeria. Older age was associated with the likelihood of being underweight, overweight and obese in all countries. Positive associations were also observed between living in better-off households, and overweight and obesity, while a negative association was observed for underweight. Breastfeeding was associated with less likelihood of underweight in DRC and Nigeria, obesity in DRC and Ghana, overweight in Kenya, and overweight and obesity in Mozambique and Nigeria relative to normal weight.

Conclusions: Our analysis reveals that in all the countries, women who are breastfeeding are less likely to be underweight, overweight and obese. Education, age and household wealth index tend to associate with a higher likelihood of DBM among women. Interventions to address DBM should take into account the variations in the effects of these correlates.

Keyword: Double burden, malnutrition, women, correlates, sub-Saharan Africa

Strengths and limitations of this study

- Large nationally representative samples used, thereby providing more robust estimates of observed associations
- The height and weight data used to compute the BMI were objectively measured, reducing possible misclassification
- Use of multi-country data helped unmask differences and commonalities in the effects of the correlates on DBM across countries
- The use of cross-sectional surveys may not allow to establish causation
- Due to data limitation, the DBM was examined only at the population or national level

Introduction

The Double Burden of Malnutrition (DBM), which is the coexistence of both undernutrition and over-nutrition in the same population across the life course is a global public health problem (1, 2). Data from the World Health Organization (WHO) indicate that in 2014, 1.9 billion adults aged 18 years and above were overweight, while over 600 million were obese globally (1). Similarly, in the same year, 462 million adults were underweight and 264 million women of reproductive age were affected by iron-amenable anaemia (2, 3). These key indicators of DBM are also increasing globally, with the low and middle income countries (LMICs) being the most affected (4). For example, while globally, obesity has doubled in the last three decades, it has tripled in LMICs in just two decades (5). An analysis of survey data from 24 African countries spanning 25 years, revealed that overweight and obesity among women are on the rise (6). Also, comparative analysis of data on women and men in the developing countries showed that DBM tends to disproportionately affect women than men (7, 8). The vulnerability of women to DBM may be attributed to their high nutritional requirements for pregnancy and lactation and also because of gender inequalities in poverty (8). Further evidence suggests that if micronutrient deficiencies are taken into account, Africa is in fact experiencing a triple burden of malnutrition (2, 3). It has been estimated that almost 50 percent of pregnant women in Africa suffer from anaemia, which increases death risk for themselves as well as their unborn babies (2).

Furthermore, the contribution of DBM to the burden of disease has been documented. The available evidence suggests that underweight and obesity are among the top ten leading risk factors for the global burden of disease (9, 10). Furthermore, more recent WHO data have

identified underweight among the top four risks factors for the burden of disease in the world, as measured in disability-adjusted life years (DALYs)—contributing up to 6% of global DALYs (10). The relationship between maternal and child weight and the consequences on disease incidence later in life have also been documented. Overweight in motherhood is associated with overweight and obesity in their offspring (2, 11). Rapid weight gain early in life may predispose to long-term weight excess or obesity. And as the evidence suggests, obesity is an important underlying cause of many non-communicable diseases (NCDs), including hypertension, diabetes, cancer, stroke, and ischemic heart disease (3, 5, 11). These diseases are responsible for most of the deaths worldwide, with LMICs disproportionately bearing the brunt, where 80% of the NCD deaths occur (2-4). Experts warned that unless countries in Africa start enacting measures to tackle the DBM affecting the continent, the road towards universal health care (UHC) will be marred with obstacles as will the aspiration to achieve health and wellbeing for all by 2030 (12).

It is important to underscore that DBM can exist at the individual, household and population levels (2). For instance, at the individual level, obesity can occur with deficiency of one or various vitamins and minerals, or overweight in an adult who was stunted during childhood. At the household level, a mother may be overweight or anaemic and a child or grandparent is underweight. DBM at the population level occurs when there is a prevalence of both under- and over-nutrition in the same community, nation or region (2). Since it will be difficult to determine individual and within households DBM using these data, our definition of DBM is at population or country level, whereby underweight and overweight/obesity co-exist in the same country. Undoubtedly, the DBM offers an important opportunity for use of multidimensional approaches in tackling malnutrition in all its

forms. Addressing the DBM will be key to achieving the Sustainable Development Goals (in particular Goal 2 and Target 3.4) and the Commitments of the Rome Declaration on Nutrition, within the UN Decade of Action on Nutrition (1). However, as a starting point, countries need to understand the key correlates of DBM. The present paper attempts to elucidate these correlates.

The factors influencing DBM are complex; ranging from biological to environmental factors (2). Some of these factors may include, poor water and sanitation systems, weak public health systems thereby thwarting efforts to reduce undernutrition (2). Also, increasing urbanization and changing dietary patterns and sedentary lifestyles, income level, older age, household wealth, higher education, place of residence among others have been identified as key contributing factors to the DBM epidemic (13-16). For example, Kamal and colleagues observed in their study that household wealth index and place of residence are key predictors of the DBM among women in Bangladesh (17). Women from the poorest wealth quintile were more likely to suffer from DBM relative to those from the richest wealth quintile. Besides, marital status, age at first childbirth, parity, household size and food security were also found to play a critical role in the DBM epidemic (14, 17, 18). The above referenced studies used data from a single country, masking differences and commonalities of the effects of the correlates on DBM across countries. The present study is intended to fill this gap.

Given the anticipated long-term effects of DBM, the factors that are associated with being underweight, overweight or obese should be considered while formulating effective interventions

to address DBM among women (15, 16). This stresses the need for prevention strategies targeted at addressing all forms of malnutrition. The present study is well positioned to provide evidence on the key correlates of DBM in SSA, which is currently lacking in the region. Understanding the role of these risk factors is key to developing clear and effective strategies for improving public health in SSA. The overarching aim of our study is to examine the correlates of DBM among women in five SSA countries.

Methodology

Sources of data and sampling procedure

Design and data sources

The study used the recent Demographic and Health Surveys (DHS) (19) data from Ghana (2014), Kenya (2014), Nigeria (2013), Mozambique (2011) and Democratic Republic of Congo (DRC) (2013-2014). These are nationally representative, repeated cross-sectional household surveys collected primarily in lower- and middle-income countries approximately every 5 years and standardized to enable cross-country comparisons (20, 21). The design of the DHS surveys is identical across all participating countries, making possible the comparisons between and across countries. The DHS utilizes a two-stage sample design (22-26). The first stage involves the selection of sample points or clusters from an updated master sampling frame constructed from National Population and Housing Census of the respective countries. The clusters are selected using systematic sampling with probability proportional to size. Household listing is then conducted in all the selected clusters to provide a sampling frame for the second stage selection of households. The second stage of

selection involves the systematic sampling of the households listed in each cluster, and households to be included in the survey are randomly selected from the list. The rationale for the second stage selection is to ensure adequate numbers of completed individual interviews to provide estimates for key indicators with an acceptable precision. All men and women aged 15-59 and 15-49 respectively, in the selected households (men in half of the households) were eligible to participate in the surveys if they were either usual residents of the household or visitors present in the household on the night before the survey. We limited our analyses to women aged 15–49 years in all countries and who have complete anthropometry data. The samples for the respective countries are as follows: DRC (9,506), Ghana (3,012), Kenya (9,993), Mozambique (11,017) and Nigeria (31,170).

Outcome and predictor variables

Outcome variables: The outcome variable of interest was women body mass index (BMI) derived from results of height and weight measurements. The Height and weight were measured objectively by trained field technicians using standard techniques (21). Weight measurements were taken using electronic Seca scales with a digital screen, while height measurements were taken using a stadiometer produced by Shorr Productions. BMI, also referred to as Quetelet's Index (27), was derived by dividing weight in kilograms by the squared height in meters. Based on the BMI (kg/m^2) estimates, and according to World Health Organization guidelines (28), the participants were classified as underweight (BMI<18.50 kg/m^2), normal weight (18.50-24.99 kg/m^2), overweight (25.0-29.9 kg/m^2) and obese (≥ 30.0 kg/m^2). The normal weight (18.50-24.99 kg/m^2) was used as reference category in the analysis.

Predictor variables: The predictor variables of interest used in the analysis included, women's age, education, employment status, breastfeeding status, parity, place of residence, marital status, women decision making autonomy (decision on large household purchases and decision on health), household size, frequency of watching TV and household wealth index. These potential correlates were identified based on literature search and further subjected to bivariate analysis (Table 2) to establish their relationship with the DBM indicators. All statistically significant variables were included in the multivariate analysis.

Analytical strategy

We utilized Multinomial logistic regression (MLR) in the analysis. MLR approach was contemplated to be suitable as the outcome measure is polychotomous by nature. Further, the MLR was considered attractive analytical technique because it does not assume normality, linearity, or homoscedasticity (29). In MLR, we observe vectors $Y = (y_1, y_2, \ldots, y_{k+1})^T$; $y_i = 0$ for all i, and one j with $y_j = 1$ and corresponding probability p_j, implying

$$EY = p,\ Cov\ Y = \Lambda_p - pp^T,\quad \Lambda_p = \begin{pmatrix} p_1 & \cdots & 0 \\ \vdots & \ldots & \vdots \\ 0 & \cdots & p_{k+1} \end{pmatrix} \qquad (1)$$

The multinomial logistic regression is given by

$$p_i = \frac{\exp\left(\pi^{(i)^T} x\right)}{1 + \sum_{j=1}^{k} \exp\left(\pi^{(i)^T} x\right)} \text{ for i = 1, ..., k} \qquad (2)$$

$$p_{k+1} = \frac{1}{1 + \sum_{j=1}^{k} \exp\left(\pi^{(i)^T} x\right)} \qquad (3)$$

Where $x = (x_1, x_2, \ldots, x_m)^T$ is the vector of covariates, and $\pi^{(i)}$ is the parameter vector corresponding to the *i*-th response category. In Equation (3), the parameters are set to zero and allows computing the probability for the base category in the MLR.

Because of the normalization condition,

$$\sum_{j=1}^{k} P(y^{(j)} = 1 | x, \pi) = 1, \quad (4)$$

the weight vector of one of the classes need not to be estimated without loss of generality, in this case the *(j+1)*-th category. To perform maximum likelihood (ML), one simply maximizes the log-likelihood function using Equation (5),

$$log \prod_{j=1}^{k+1} p_j^{y_j} = \sum_{j=1}^{k} y_j \pi^{(i)^T} x - log\left[1 + \sum_{j=1}^{k} \exp\left(\pi^{(i)^T} x\right)\right] \quad (5)$$

The MLR model was constructed to investigate the net effects of the correlates on underweight, overweight, and obesity. Using a BMI category of 18.5–24.99 kg/m2 (normal weight) as the reference, a set of logistic regressions for underweight, overweight and obese categories was estimated in which, each of the categories was contrasted with the reference category. Since there was no candidate predictor variable, all covariates were simultaneously entered into the model. Results were presented in the form of coefficients with significance levels and 95% confidence intervals (95% CI).

Results

Descriptive

Table 1 and 2 present the characteristics of the samples. The results in Table 1 shows that among the five countries, Mozambique had the highest number of normal weight women (78%) followed by DRC (74%), with Ghana having the lowest (59%). Kenya (12%) and DRC (13%) had the highest prevalence of underweight women, while Ghana had the highest number of overweight (23%) and obese (12%) women. In all the countries analysed, the prevalence of overweight and obesity had overtaken underweight. Women in Kenyan data had more years of education, while Mozambique had women with the least years of education (Table 2). The age of study participants was fairly the same across all the five countries and ranged from 28 years in Mozambique and Kenya to 30 years in Ghana. Further, among all the countries, Ghana had the highest number of women who were working (79%), while Mozambique had the lowest (39%).

Table 1: Characteristics of the BMI samples

Variables	DRC Mean/%	Ghana Mean/%	Kenya Mean/%	Mozambique Mean/%	Nigeria Mean/%
Body mass index (BMI)					
BMI=18.50-24.99 (normal weight)	73.50	59.20	62.00	77.60	66.10
BMI<18.50 (underweight)	12.70	5.30	11.80	5.70	8.70
BMI= 25-29.99 (overweight)	11.50	23.40	18.90	13.70	18.30
BMI>=30 (obesity)	2.30	12.20	7.30	3.00	7.00

Table 2: Characteristics of the samples, categorical and continuous variables

Variables	DRC Mean/%	Ghana Mean/%	Kenya Mean/%	Mozambique Mean/%	Nigeria Mean/%
Women's Education (in years)	5.179***	6.018***	7.571***	3.063***	4.722***
	(0.120)	(0.188)	(0.093)	(0.082)	(0.125)
Women's Age (in years)	29.20***	30.57***	28.60***	28.57***	29.37***
	(0.117)	(0.201)	(0.103)	(0.119)	(0.0782)
Household wealth index					
Poorest	22.4***	22.7***	23.4***	23.6***	23.5***

	(0.012)	(0.016)	(0.010)	(0.012)	(0.012)
Poorer	23.0***	19.8***	20.3***	21.4***	23.1***
	(0.014)	(0.012)	(0.008)	(0.008)	(0.009)
Middle	20.6***	20.6***	18.5***	20.0***	18.9***
	(0.010)	(0.014)	(0.007)	(0.009)	(0.008)
Rich	18.6***	18.7***	18.2***	19.9***	17.8***
	(0.016)	(0.015)	(0.008)	(0.009)	(0.007)
Richest	15.5***	18.2***	19.6***	15.1***	16.8***
	(0.014)	(0.017)	(0.011)	(0.008)	(0.008)
Respondent currently working (yes)	74.9***	78.8***	63.6***	39.3***	68.9***
	(0.016)	(0.014)	(0.010)	(0.011)	(0.008)
Place of residence (urban)	29.9***	45.4***	36.1***	27.5***	35.0***
	(0.018)	(0.020)	(0.011)	(0.011)	(0.011)
Household head (Female)	21.6***	26.0***	30.4***	30.3***	9.7***
	(0.009)	(0.015)	(0.009)	(0.008)	(0.004)
Parity	4.434***	3.552***	3.540***	3.928***	4.328***
	(0.049)	(0.067)	(0.043)	(0.041)	(0.034)
Household size	6.826***	5.573***	5.626***	5.967***	7.007***
	(0.085)	(0.093)	(0.057)	(0.053)	(0.061)
Frequency of watching TV					
Not at all	66.4***	19.6***	22.0***	34.5***	39.8***
	(0.014)	(0.015)	(0.008)	(0.009)	(0.010)
Less than once a week	14.6***	32.7***	12.5***	23.2***	25.0***
	(0.009)	(0.016)	(0.006)	(0.007)	(0.008)
At least once a week	19.0***	47.7***	65.5***	42.3***	35.2***
	(0.011)	(0.017)	(0.010)	(0.010)	(0.009)
Currently breastfeeding (yes)	68.6***	57.8***	54.0***	60.8***	54.8***
	(0.009)	(0.016)	(0.009)	(0.008)	(0.006)
Marital status					
Never Married	4.3***	7.1***	7.1***	4.2***	1.6***
	(0.005)	(0.008)	(0.004)	(0.003)	(0.001)
Married or Cohabiting	87.2***	86.5***	83.7***	84.3***	95.9***
	(0.007)	(0.011)	(0.006)	(0.006)	(0.002)
Formerly in union	8.5***	6.4***	9.2***	11.5***	2.6***
	(0.006)	(0.007)	(0.005)	(0.005)	(0.001)
Decision on large household purchases					
Respondent alone	8.7***	20.8***	29.1***	17.2***	4.7***
	(0.007)	(0.014)	(0.008)	(0.007)	(0.003)
Both Respondent and partner	31.0***	42.7***	34.2***	39.1***	29.2***
	(0.015)	(0.020)	(0.009)	(0.009)	(0.009)
Partner alone	47.3***	22.2***	20.1***	27.5***	61.6***
	(0.015)	(0.017)	(0.007)	(0.009)	(0.010)
Someone else/Other	0.2***	0.9***	0.4***	0.6***	0.2***
	(0.001)	(0.002)	(0.001)	(0.001)	(0.0004)
Decision on respondent's health					
Respondent alone	13.8***	16.3***	14.7***	10.00***	4.34***
	(0.010)	(0.012)	(0.006)	(0.005)	(0.002)
Both Respondent and partner	37.2***	44.8***	42.2***	38.2***	28.4***

	(0.013)	(0.018)	(0.010)	(0.009)	(0.009)
Partner alone	35.6***	24.4***	26.3***	35.4***	62.8***
	(0.015)	(0.015)	(0.009)	(0.009)	(0.010)
Someone else/Other	0.3***	1.0***	0.4***	0.7***	0.2***
	(0.001)	(0.003)	(0.001)	(0.001)	(0.0004)
Observations	9,506	3,012	9,993	11,017	31,170

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Multivariate

Tables 3-7 present the MLR results of the correlates of DBM among women in DRC, Ghana, Kenya, Mozambique and Nigeria. The results showed a significant positive relationship between women's years' of education and overweight in Ghana, overweight and obesity in Mozambique and Nigeria. Thus, compared with normal weight women, an additional year of education was associated with a higher likelihood of overweight and obesity in Ghana, Mozambique and Nigeria. Conversely, number of years of education was associated negatively with underweight in Kenya and Nigeria relative to normal weight. Also, older age was significantly and positively associated with underweight, overweight and obesity compared to normal weight women in all countries included in the analysis. An exception could be made of Nigeria where older age was inversely related to underweight. The results in relation to household wealth index were mixed. While generally, significant positive associations were observed between wealth index (middle, richer and richest quintiles) and overweight and obesity in all the five countries, inverse relationship was observed for underweight. Compared to normal weight women, higher maternal parity was inversely related to underweight in Ghana and Mozambique, and both underweight and overweight in Kenya. In DRC, maternal parity was inversely related to underweight and positively related to obesity. Breastfeeding was associated with less likelihood of underweight among women in DRC and

Nigeria, obesity in DRC and Ghana, overweight in Kenya, and overweight and obesity in Mozambique and Nigeria relative to normal weight women.

Table 3: Multivariate analysis of the association between sociodemographic correlates and malnutrition, DRC

Variables	Underweight (BMI<18.50)	Overweight (BMI=25-29.99)	Obesity (BMI >=30)
Women's Education (in years)	0.030*	-0.011	-0.023
	(-0.004 - 0.064)	(-0.052 - 0.030)	(-0.093 - 0.047)
Women's Age (in years)	0.041***	0.034**	-0.045
	(0.015 - 0.068)	(0.007 - 0.060)	(-0.104 - 0.015)
Household wealth Index			
Poorest (reference)			
Poorer	-0.009	-0.069	-0.241
	(-0.306 - 0.288)	(-0.488 - 0.351)	(-1.575 - 1.094)
Middle	-0.144	0.421**	0.570
	(-0.534 - 0.247)	(0.039 - 0.804)	(-0.529 - 1.669)
Rich	-0.480**	0.803*	2.365***
	(-0.942 - -0.018)	(0.345 - 1.261)	(1.225 - 3.505)
Richest	-1.017***	1.486*	4.014***
	(-1.564 - -0.471)	(0.985 - 1.987)	(2.562 - 5.465)
Woman currently working (yes)	0.226	-0.462***	-0.350
	(-0.052 - 0.504)	(-0.794 - -0.131)	(-0.850 - 0.149)
Place of residence (urban)	-0.246	0.034	-0.094
	(-0.601 - 0.108)	(-0.350 - 0.417)	(-0.810 - 0.622)
Sex of household head (female)	-0.0453	0.167	0.363
	(-0.377 - 0.286)	(-0.144 - 0.478)	(-0.380 - 1.105)
Parity	-0.122***	0.0335	0.350***
	(-0.199 - -0.045)	(-0.040 - 0.107)	(0.174 - 0.525)
Household size	-0.019	-0.008	-0.052
	(-0.066 - 0.028)	(-0.048 - 0.031)	(-0.158 - 0.056)
Frequency of watching TV			
Not at all (reference)			
Less than once a week	0.089	0.165	-0.209
	(-0.251 - 0.429)	(-0.192 - 0.522)	(-0.912 - 0.494)
At least once a week	-0.163	0.180	0.149
	(-0.623 - 0.298)	(-0.140 - 0.500)	(-0.373 - 0.671)
Currently breastfeeding	0.327***	-0.010	-0.512**
	(0.082 - 0.572)	(-0.361 - 0.164)	(-1.020 - -0.005)
Marital status			
Never in union (reference)			
Married or Cohabiting	-0.766*	0.809*	0.248

	(-1.567 - 0.0347)	(0.132 - 1.486)	(-1.131 - 1.626)
Formerly in union	-0.357	0.0680	-0.549
	(-1.126 - 0.413)	(-0.583 - 0.718)	(-1.956 - 0.859)
Decision on large household purchases			
Respondent alone (reference)			
Both Respondent and partner	0.186	0.155	0.885*
	(-0.292 - 0.664)	(-0.291 - 0.601)	(-0.154 - 1.923)
Partner alone	0.436*	0.098	0.423
	(-0.059 - 0.931)	(-0.325 - 0.522)	(-0.370 - 1.215)
Someone else/Other	-0.787	-3.160***	-12.640***
	(-2.567 - 0.993)	(-5.513 - -0.808)	(-14.160 - -11.130)
Decision on respondent's health			
Respondent alone (reference)			
Both Respondent and partner	-0.180	-0.332	-0.743*
	(-0.599 - 0.239)	(-0.731 - 0.067)	(-1.594 - 0.109)
Partner alone	-0.176	-0.525**	-0.602*
	(-0.552 - 0.201)	(-0.933 - -0.116)	(-1.282 - 0.078)
Someone else/Other	1.672**	0.687	-14.200***
	(0.073 - 3.272)	(-1.990 - 3.363)	(-15.970 - -12.430)
Observations	9,506	9,506	9,506

Confidence Intervals (CI) in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Multivariate analysis of the association between sociodemographic correlates and malnutrition, Ghana

Variables	Underweight BMI<18.50	Overweight BMI=25-29.99	Obesity BMI>= 30
Women's Education (in years)	-0.022	0.074***	0.028
	(-0.080 - 0.036)	(0.037 - 0.110)	(-0.014 - 0.070)
Women's Age (in years)	0.054**	0.0405**	0.083***
	(0.005 - 0.103)	(0.008 - 0.073)	(0.048 - 0.118)
Household wealth index			
Poorest (reference)			
Poorer	-0.398	0.367	1.390***
	(-0.972 - 0.177)	(-0.129 - 0.864)	(0.582 - 2.197)
Middle	-1.050***	0.893*	2.804***
	(-1.768 - -0.331)	(0.340 - 1.447)	(1.947 - 3.662)
Rich	-0.529	1.436*	3.591***
	(-1.426 - 0.369)	(0.878 - 1.995)	(2.615 - 4.568)
Richest	-1.788***	1.271*	4.121***
	(-3.052 - -0.523)	(0.555 - 1.988)	(3.125 - 5.117)
Woman currently working (yes)	-0.125	0.121	0.0769
	(-0.713 - 0.463)	(-0.238 - 0.481)	(-0.424 - 0.577)

Place of residence (urban)	0.463*	0.113	-0.073
	(-0.0488 - 0.975)	(-0.250 - 0.477)	(-0.582 - 0.435)
Sex of household head (female)	0.409	0.0971	0.293
	(-0.276 - 1.093)	(-0.309 - 0.503)	(-0.173 - 0.759)
Parity	-0.205**	0.0719	0.0324
	(-0.372 - -0.038)	(-0.055 - 0.199)	(-0.118 - 0.183)
Household size	0.021	-0.047	0.035
	(-0.045 - 0.086)	(-0.121 - 0.027)	(-0.077 - 0.147)
Frequency of watching TV			
Not at all (reference)			
Less than once a week	-0.043	0.231	0.673*
	(-0.604 - 0.518)	(-0.240 - 0.703)	(0.0003 - 1.345)
At least once a week	-0.233	0.248	0.756**
	(-0.754 - 0.287)	(-0.184 - 0.679)	(0.146 - 1.365)
Currently breastfeeding (yes)	0.136	-0.177	-0.471**
	(-0.364 - 0.637)	(-0.525 - 0.171)	(-0.832 - -0.110)
Marital status			
Never in union (reference)			
Married or Cohabiting	-0.536	-0.259	0.295
	(-1.843 - 0.772)	(-0.904 - 0.386)	(-0.860 - 1.451)
Formerly in union	0.271	0.420	1.435*
	(-0.837 - 1.378)	(-0.286 - 1.126)	(0.400 - 2.470)
Decision on large household purchases			
Respondent alone (reference)			
Both Respondent and partner	0.464	-0.0143	-0.0496
	(-0.555 - 1.483)	(-0.523 - 0.495)	(-0.657 - 0.557)
Partner alone	0.664	-0.0223	-0.265
	(-0.217 - 1.546)	(-0.556 - 0.512)	(-0.917 - 0.386)
Someone else/Other	-1.212	-0.0290	0.752
	(-3.637 - 1.213)	(-1.485 - 1.426)	(-1.161 - 2.665)
Decision on respondent's health			
Respondent alone (reference)			
Both Respondent and partner	0.0525	0.785*	0.787*
	(-0.868 - 0.973)	(0.280 - 1.290)	(0.166 - 1.408)
Partner alone	0.119	0.526*	0.915*
	(-0.643 - 0.881)	(-0.0457 - 1.098)	(0.156 - 1.675)
Someone else/Other	-0.714	-1.544	-13.43***
	(-2.832 - 1.403)	(-3.520 - 0.433)	(-15.04 - -11.81)
Observations	3,012	3,012	3,012

Confident Intervals (CI) in parentheses

*** p<0.01, ** p<0.05, * p<0.1

Table 5: Multivariate analysis of the association between sociodemographic correlates and malnutrition, Kenya

Variables	Underweight (BMI<18.50)	Overweight (BMI=25.29.99)	Obesity (BMI>=30)
Women's Education (in years)	-0.113***	0.013	0.013
	(-0.148 - -0.078)	(-0.016 - 0.042)	(-0.030 - 0.056)
Women's Age (in years)	0.026**	0.066***	0.120***
	(0.001 - 0.052)	(0.046 - 0.089)	(0.087 - 0.153)
Household wealth index			
Poorest (reference)			
Poorer	-0.488***	0.279*	0.633*
	(-0.805 - -0.172)	(-0.025 - 0.582)	(0.080 - 1.187)
Middle	-0.500***	0.609***	0.790*
	(-0.869 - -0.130)	(0.261 - 0.957)	(0.268 - 1.311)
Rich	-0.940***	0.927*	1.690***
	(-1.376 - -0.504)	(0.578 - 1.276)	(1.164 - 2.216)
Richest	-1.307***	1.427***	2.616***
	(-1.946 - -0.668)	(1.042 - 1.813)	(2.049 - 3.184)
Woman currently working (yes)	-0.357***	0.0162	0.210
	(-0.590 - -0.123)	(-0.221 - 0.253)	(-0.110 - 0.529)
Place of residents (urban)	0.0337	0.107	0.497***
	(-0.272 - 0.339)	(-0.115 - 0.330)	(0.177 - 0.817)
Sex of household head (female)	0.230	0.0205	-0.0346
	(-0.0570 - 0.518)	(-0.177 - 0.218)	(-0.336 - 0.267)
Parity	-0.164***	-0.118***	-0.084
	(-0.243 - -0.085)	(-0.190 - -0.046)	(-0.199 - 0.030)
Household size	-0.035	0.013	0.034
	(-0.089 - 0.019)	(-0.034 - 0.061)	(-0.044 - 0.111)
Frequency of watching TV			
Not at all			
Less than once a week	-0.539***	0.076	-0.131
	(-0.905 - -0.174)	(-0.295 - 0.447)	(-0.700 - 0.439)
At least once a week	-0.066	0.043	0.035
	(-0.355 - 0.223)	(-0.194 - 0.281)	(-0.357 - 0.426)
Currently breastfeeding (yes)	0.102	-0.156*	-0.204
	(-0.112 - 0.316)	(-0.338 - 0.026)	(-0.510 - 0.102)
Marital status			
Never in union (reference)			
Married or Cohabiting	0.299	0.870*	0.898*
	(-0.197 - 0.794)	(0.422 - 1.317)	(0.212 - 1.584)
Formerly in union	0.209	0.488**	0.312
	(-0.339 - 0.756)	(0.047 - 0.929)	(-0.392 - 1.017)
Decision on household large purchases			
Respondent alone (reference)			
Both Respondent and partner	-0.217	-0.303**	0.0495
	(-0.546 - 0.113)	(-0.543 - -0.063)	(-0.259 - 0.358)

Partner alone	-0.298*	-0.0677	-0.128
	(-0.641 - 0.045)	(-0.350 - 0.215)	(-0.528 - 0.273)
Someone else/Other	-2.309***	-0.970	-13.66***
	(-4.053 - -0.565)	(-3.170 - 1.231)	(-14.580 - -12.730)
Decision on respondent's health			
Respondent alone (reference)			
Both Respondent and partner	-0.0559	0.0704	-0.131
	(-0.427 - 0.315)	(-0.194 - 0.335)	(-0.524 - 0.262)
Partner alone	-0.220	-0.016	-0.183
	(-0.601 - 0.161)	(-0.301 - 0.268)	(-0.633 - 0.266)
Someone else/Other	-2.446***	0.092	-12.920***
	(-4.226 - -0.666)	(-2.677 - 2.862)	(-14.610 - -11.230)
Observations	9,993	9,993	9,993

Confidence Intervals (CI) in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Multivariate analysis of the association between sociodemographic correlates and malnutrition, Mozambique

Variables	Underweight (BMI<18.50)	Overweight (BMI=25-29.99)	Obesity (BMI>=30)
Women's Education (yes)	0.011	0.044***	0.098***
	(-0.041 - 0.063)	(0.0127 - 0.076)	(0.041 - 0.156)
Women's Age (in years)	0.018	0.032***	0.075***
	(-0.013 - 0.049)	(0.012 - 0.052)	(0.042 - 0.109)
Household Wealth index			
Poorest (reference)			
Poorer	-0.146	0.618*	1.061
	(-0.479 - 0.187)	(0.222 - 1.015)	(-0.529 - 2.650)
Middle	-0.741***	0.856*	2.424***
	(-1.118 - -0.365)	(0.430 - 1.282)	(1.023 - 3.825)
Rich	-0.618***	1.235*	2.905***
	(-1.081 - -0.154)	(0.818 - 1.652)	(1.576 - 4.234)
Richest	-0.800***	1.977***	4.832***
	(-1.408 - -0.192)	(1.517 - 2.437)	(3.496 - 6.168)
Woman currently working (yes)	0.195	-0.0795	0.014
	(-0.087 - 0.477)	(-0.271 - 0.112)	(-0.371 - 0.400)
Place of residence (urban)	0.0766	-0.0722	-0.0180
	(-0.306 - 0.459)	(-0.350 - 0.205)	(-0.504 - 0.468)
Sex of household head (female)	-0.342**	-0.056	-0.142
	(-0.649 - -0.036)	(-0.264 - 0.153)	(-0.570 - 0.286)
Parity	-0.124**	0.0379	0.160**
	(-0.224 - -0.023)	(-0.024 - 0.100)	(0.037 - 0.282)
Household size	0.0161	-0.010	-0.037
	(-0.037 - 0.070)	(-0.042 - 0.022)	(-0.108 - 0.035)
Frequency of watching TV			

Not at all (reference)			
Less than once a week	-0.0113	0.157	0.630***
	(-0.328 - 0.306)	(-0.091 - 0.404)	(0.214 - 1.047)
At least once a week	-0.214	-0.0124	0.044
	(-0.518 - 0.0895)	(-0.213 - 0.188)	(-0.329 - 0.418)
Currently breastfeeding	0.215	-0.298***	-0.516**
	(-0.049 - 0.478)	(-0.493 - -0.102)	(-0.938 - -0.0944)
Marital status			
Never in union (reference)			
Married or Cohabiting	0.253	0.196	0.708*
	(-0.419 - 0.925)	(-0.223 - 0.615)	(-0.0469 - 1.462)
Formerly in union	0.351	-0.029	0.773**
	(-0.288 - 0.989)	(-0.462 - 0.404)	(0.0197 - 1.527)
Decision on large household purchases			
Respondent alone (reference)			
Both Respondent and partner	-0.096	-0.0634	-0.0414
	(-0.472 - 0.281)	(-0.329 - 0.202)	(-0.647 - 0.564)
Partner alone	-0.049	0.037	-0.366
	(-0.420 - 0.323)	(-0.256 - 0.329)	(-1.022 - 0.289)
Someone else/Other	0.036	0.746	-0.983
	(-1.044 - 1.115)	(-0.600 - 2.091)	(-3.268 - 1.303)
Decision on respondent's health			
Respondent alone (reference)			
Both Respondent and partner	-0.184	-0.134	-0.143
	(-0.633 - 0.265)	(-0.425 - 0.158)	(-0.777 - 0.491)
Partner alone	-0.317	-0.148	0.227
	(-0.786 - 0.151)	(-0.440 - 0.144)	(-0.360 - 0.814)
Someone else/Other	-0.480	-0.646	-1.232
	(-1.477 - 0.516)	(-1.649 - 0.357)	(-3.319 - 0.855)
Observations	11,017	11,017	11,017

Confidence Intervals (CI) in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Multivariate analysis of the association between sociodemographic correlates and malnutrition, Nigeria

Variable	Underweight (BMI<18.50)	Overweight (BMI=25-29.99)	Obesity (BMI>=30)
Women's Education (in years)	-0.042***	0.034***	0.048***
	(-0.067 - -0.018)	(0.019 - 0.049)	(0.028 - 0.068)
Women's Age (in years)	-0.019**	0.040***	0.072***
	(-0.035 - -0.0021)	(0.030 - 0.051)	(0.056 - 0.088)
Household wealth index			
Poorest (reference)			

Poorer	-0.200**	0.289***	0.208
	(-0.366 - -0.034)	(0.090 - 0.488)	(-0.280 - 0.697)
Middle	-0.291**	0.691***	0.788*
	(-0.517 - -0.0650)	(0.479 - 0.903)	(0.298 - 1.278)
Rich	-0.208	0.998*	1.196*
	(-0.477 - 0.0614)	(0.764 - 1.232)	(0.694 - 1.698)
Richest	-0.530***	1.351***	1.862***
	(-0.921 - -0.139)	(1.074 - 1.628)	(1.353 - 2.372)
Woman currently working (yes)	-0.0518	0.0231	-0.292***
	(-0.198 - 0.0944)	(-0.102 - 0.148)	(-0.497 - -0.0878)
Place of residence (urban)	0.166	0.0775	0.178*
	(-0.0500 - 0.381)	(-0.0643 - 0.219)	(-0.0244 - 0.379)
Sex of household head (female)	-0.0836	0.0127	-0.084
	(-0.336 - 0.169)	(-0.149 - 0.174)	(-0.300 - 0.133)
Parity	-0.011	0.039**	0.0230
	(-0.0538 - 0.0313)	(0.009 - 0.0698)	(-0.021 - 0.067)
Household size	0.007	-0.009	0.023*
	(-0.015 - 0.029)	(-0.025 - 0.00654)	(-0.002 - 0.047)
Frequency of watching TV			
Not at all (reference)			
Less than once a week	-0.146	0.0771	0.0585
	(-0.336 - 0.045)	(-0.056 - 0.210)	(-0.162 - 0.278)
At least once a week	-0.252***	0.155**	0.205*
	(-0.438 - -0.066)	(0.024 - 0.285)	(-0.009 - 0.420)
Currently breastfeeding	0.178***	-0.176***	-0.363***
	(0.043 - 0.314)	(-0.278 - -0.073)	(-0.524 - -0.202)
Marital status			
Never in union			
Married or Cohabiting	-0.177	0.633*	0.557*
	(-0.652 - 0.299)	(0.188 - 1.078)	(-0.090 - 1.204)
Formerly in union	0.0721	0.921*	1.071*
	(-0.400 - 0.545)	(0.426 - 1.416)	(0.417 - 1.724)
Decision on large household purchases			
Respondent alone			
Both Respondent and partner	-0.206	0.0218	0.341*
	(-0.641 - 0.230)	(-0.209 - 0.252)	(-0.002 - 0.684)
Partner alone	-0.181	-0.015	-0.177
	(-0.579 - 0.218)	(-0.238 - 0.209)	(-0.538 - 0.184)
Someone else/Other	1.314*	-0.651	-0.225
	(-0.239 - 2.866)	(-1.912 - 0.609)	(-1.731 - 1.281)
Decision on respondent's health			
Respondent alone (reference)			
Both Respondent and partner	-0.0847	-0.0141	-0.192
	(-0.525 - 0.356)	(-0.251 - 0.223)	(-0.547 - 0.163)
Partner alone	0.069	0.025	-0.088
	(-0.334 - 0.474)	(-0.206 - 0.256)	(-0.460 - 0.283)

Someone else/Other	-2.381*** (-1.417 - -0.423)	-1.369** (-4.688 - -3.669)	-2.604** (-7.160 - -5.311)
Observations	31,170	31,170	31,170

Confidence Intervals (CI) in parentheses
*** p<0.01, ** p<0.05, * p<0.1

The figures 1 and 2 are pictorial presentations of the probability of women falling into underweight, overweight and obese categories if there were changes in their age and years of education.

Figure 1: Graphical Illustration of the results of the probability of falling into the DBM categories when years of education increase

Figure 2: Graphical Illustration of results of the probability of falling into the DBM categories when age increases

Discussion

This study investigated the correlates of DBM among women in five SSA countries. The key indicators of DBM used in the analysis were, underweight, overweight and obesity. The results showed expectedly that there are some variations across countries on how the correlates included in this study are associated with DBM. Our analysis reveals that in Ghana, Mozambique and Nigeria, number of years of formal education was associated significantly and positively with overweight and obesity. Suggesting that compared to normal weight women, a higher number of years in education is associated with the likelihood of overweight and obesity in women. In effect, education tends to be a risk factor for women with unhealthy weight. This could be due to lifestyles changes as one achieve more years of education, which may include sedentary lifestyles and

dietary patterns (30). Further, it could be that people who are already overweight or obese have higher propensity of adding more weight relative to those who have normal weight. Contrariwise, there was an inverse relationship between number of years of formal education and underweight in Kenya and Nigeria. These findings are in line with previous studies. In Ghana, higher education was associated with overweight and obesity among women (31). Additionally, education was found to associate positively with overweight among women in Indonesia (32). However, in the same study, high education was associated with reduced risk of being underweight by 10–30% (32). This is contrary to our findings in Kenya and Nigeria.

Furthermore, age was associated positively with all the DBM indicators across the five countries. Thus, older women are more likely to be overweight and obese and less likely to be underweight. This suggests that old age is a protective factor for underweight, while a risk factor for overweight and obesity. This positive correlation between age and overweight and obesity, may have a consequential effect on non-communicable diseases (NCDs) among older people, as an unhealthy weight is a major risk factor for NCDs (33-36). An exception to these findings could be made of Nigeria where older age was associated negatively with underweight women. This implies that in this setting, the older women become the more likelihood that they will suffer from underweight. The consequential effect of this may be poor health outcomes, especially for women of reproductive age. The reason is that being underweight exposes women to higher risks of morbidity and mortality during pregnancy and child birth (37-39). The relationship between age and DBM has been documented in previous studies. For example, Doku and Neupane observed a significant positive association between age and the key indicators of DBM in Ghana (31). A study

in Bangladesh observed a significant positive relationship between older age and DBM (40). These findings together with the findings from our study confirmed the contribution of age to the DBM epidemic.

Our analysis showed that household wealth index had mixed effects on DBM. In general, the three rich quintiles: middle, richer and richest were associated significantly and positively with overweight and obesity among women across all the countries included in the analysis. This may be due to obesogenic effects of increased household wealth as dietary pattern changes (41), and the fact that there is a documented positive correlation between household wealth and unhealthy body weight (42, 43). In Bangladesh and Nepal, higher household wealth was associated with an increased likelihood of being overweight and obese (42). Also, being rich was associated with overweight and obesity among Ghanaian women (31). Interestingly, higher household wealth had an inverse effect on underweight. This inverse relationship may be due to the fact that most underweight women are likely to be in the poorer wealth quintiles (44) and therefore, may be unaffected by the higher household wealth quintiles. The inverse relationship has been observed previously (45). Relatedly, compared to the richest, women from the poorest households were significantly most likely to be underweight and least likely to be overweight over normal weight in Bangladesh (17). Suggesting that being in the poorest household is protective against overweight but not underweight (44).

The health benefits of breastfeeding were illuminated in this study. Breastfeeding was found to associate with less likelihood of underweight, overweight and obesity in the five countries analysed. This suggests that mothers who have unhealthy weight should be encourage to practice breastfeeding as the benefits are not only to their offspring but also for their own health and wellbeing. These findings confirm the widely recognized benefits of breastfeeding for improved health and developmental outcomes in mothers and their infants (46-49). The implication of this may be that interventions to promote breastfeeding may have positive impact on the DBM epidemic at the national level. The benefits of breastfeeding to women health have previously been documented. For example, breastfeeding has been suggested as an efficient means of promoting postpartum weight loss due to its high energy cost (50). Further evidence suggest that at 12 weeks postpartum, exclusively breastfeeding (EBF) mothers had lost more total body weight than mixed feeding mothers. However, mixed feeding mothers lost slightly more percent body fat than exclusively breastfeeding mothers (50).The authors concluded that EBF promotes greater weight loss than mixed feeding among mothers even in the early postpartum period. Several other studies have shown that EBF influences postpartum weight loss (49-52). The preceding discussion points to the need for health policy makers to design programmes to encourage mothers to breastfeed, especially, practice exclusive breastfeeding as a means of DBM prevention.

An important strength of our study is the use of large nationally representative samples, thereby providing more robust estimates of observed associations as well as enhancing the generalizability of the findings. The use of multi-country data help unmask differences and commonalities in the effects of the correlates on DBM across countries, which would not have been possible with single

country data. Additionally, the height and weight data which were used to compute the BMI were objectively measured, reducing possible misclassification. A limitation worth mentioning is the cross-sectional nature of the data, which does not lends itself to the establishments of causal relationship between the predictor and outcome variables. The conclusions in the paper are therefore interpreted as mere associations between the predictor variables and the outcome variable. Another limitation is that due to data limitation, we were not able to examine DBM at the individual and within households. The analysis and interpretation in this paper are therefore limited to DBM at population or national level, whereby underweight, overweight and obesity co-exist in the same country.

Conclusions

The study investigated the correlates of the DBM in five SSA countries. The analysis revealed that the effects of the correlates on DBM are largely similar across countries, except in few cases where there were disparities in the effects. The results indicate that higher number of years of education increases the likelihood of overweight and obesity among women in Ghana, Mozambique and Nigeria. Conversely, number of years of education is associated negatively with underweight in Kenya and Nigeria. Living in better-off households increases significantly the likelihood of overweight and obesity among women across all countries, while associated with the likelihood of underweight. Interventions to address DBM should take into account socioeconomic status. This may include providing special programmes for women who have unhealthy weight in wealthy households. Old age is also associated significantly and positively with underweight, overweight and obesity in all the countries included in the analysis. Breastfeeding is associated with least

likelihood of underweight, overweight and obesity in breastfeeding mothers. This implies that interventions to prevent DBM should incorporate breastfeeding to enhance their effectiveness.

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Competing Interest

The authors have no competing interests to declare.

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Data Sharing Statement

This study was a re-analysis of existing data that are publicly available from The DHS Program at http://dhsprogram.com/publications/publication-fr221-dhs-final-reports.cfm. Data are accessible free of charge upon a registration with the Demographic and Health Survey program (The DHS Program). The registration is done on the DHS website indicated above.

Authors' Contribution

DAA conceived and designed the study. DAA and ZTD conducted the data analysis, interpreted the results and drafted the manuscript. CK contributed to study design, data analysis, interpretation, and critical revision of the manuscript. All authors take responsibility of any issues that might arise from the publication of this manuscript.

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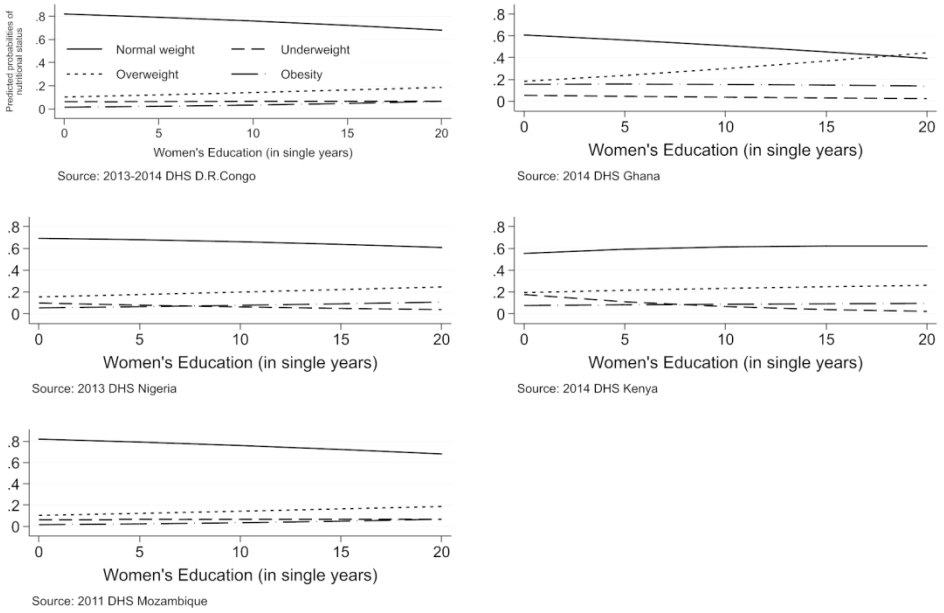

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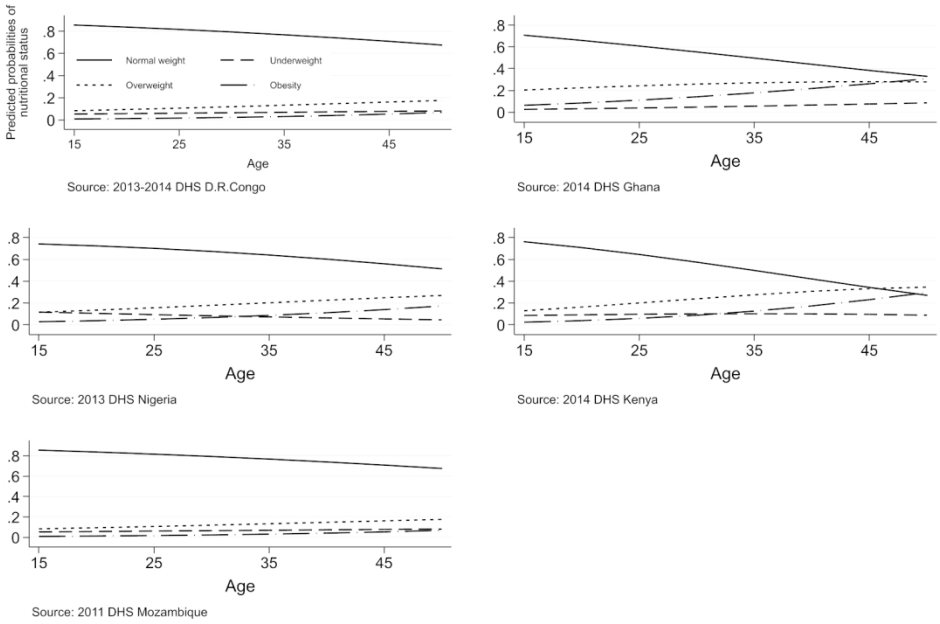

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6-
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	7-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-9
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9-10
		(*b*) Describe any methods used to examine subgroups and interactions	9-10
		(*c*) Explain how missing data were addressed	9-10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	NA
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-12
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	NA
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-10
		(*b*) Report category boundaries when continuous variables were categorized	10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	21
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	24
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	21-24
Generalisability	21	Discuss the generalisability (external validity) of the study results	25
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	NA

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Correlates of the double burden of malnutrition among women: an analysis of cross sectional survey data from sub-Saharan Africa

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Abstract

Objective: To investigate the correlates of the double burden of malnutrition (DBM) among women in five sub-Saharan African countries

Design: Secondary analysis of Demographic and Health Surveys (DHS). The outcome variable was body mass index (BMI), a measure of DBM. The BMI was classified into underweight (BMI<18.50 kg/m^2), normal weight (18.50-24.99 kg/m^2), overweight (25.0-29.9 kg/m^2) and obesity (≥ 30.0 kg/m^2).

Settings: Ghana, Nigeria, Kenya, Mozambique and Democratic Republic of Congo (DRC).

Subjects: Women aged 15-49 years (*n* 64,698).

Results: Compared with normal weight women, number of years of formal education was associated with the likelihood of being overweight and obese in Ghana, Mozambique and Nigeria, while associated with the likelihood of being underweight in Kenya and Nigeria. Older age was associated with the likelihood of being underweight, overweight and obese in all countries. Positive associations were also observed between living in better-off households, and overweight and obesity, while a negative association was observed for underweight. Breastfeeding was associated with less likelihood of underweight in DRC and Nigeria, obesity in DRC and Ghana, overweight in Kenya, and overweight and obesity in Mozambique and Nigeria relative to normal weight.

Conclusions: Our analysis reveals that in all the countries, women who are breastfeeding are less likely to be underweight, overweight and obese. Education, age and household wealth index tend to associate with a higher likelihood of DBM among women. Interventions to address DBM should take into account the variations in the effects of these correlates.

Keyword: Double burden, malnutrition, women, correlates, sub-Saharan Africa

Strengths and limitations of this study

- Large nationally representative samples used, thereby providing more robust estimates of observed associations
- The height and weight data used to compute the BMI were objectively measured, reducing possible misclassification
- Use of multi-country data helped unmask differences and commonalities in the effects of the correlates on DBM across countries
- The use of cross-sectional surveys may not allow to establish causation
- Due to data limitation, the DBM was examined only at the population or national level

Introduction

The Double Burden of Malnutrition (DBM), which is the coexistence of both undernutrition and over-nutrition in the same population across the life course is a global public health problem (1, 2). Data from the World Health Organization (WHO) indicate that in 2014, 1.9 billion adults aged 18 years and above were overweight, while over 600 million were obese globally (1). Similarly, in the same year, 462 million adults were underweight and 264 million women of reproductive age were affected by iron-amenable anaemia (2, 3). These key indicators of DBM are also increasing globally, with the low and middle income countries (LMICs) being the most affected (4). For example, while globally, obesity has doubled in the last three decades, it has tripled in LMICs in just two decades (5). An analysis of survey data from 24 African countries spanning 25 years, revealed that overweight and obesity among women are on the rise (6). Also, comparative analysis of data on women and men in the developing countries showed that DBM tends to disproportionately affect women than men (7, 8). The vulnerability of women to DBM may be attributed to their high nutritional requirements for pregnancy and lactation and also because of gender inequalities in poverty (8). Further evidence suggests that if micronutrient deficiencies are taken into account, Africa is in fact experiencing a triple burden of malnutrition (2, 3). It has been estimated that almost 50 percent of pregnant women in Africa suffer from anaemia, which increases the risk of death for themselves as well as their unborn babies (2).

Furthermore, the contribution of DBM to the burden of disease has been documented. The available evidence suggests that underweight and obesity are among the top ten leading risk factors for the global burden of disease (9, 10). Furthermore, more recent WHO data have

identified underweight among the top four risks factors for the burden of disease in the world, as measured in disability-adjusted life years (DALYs)—contributing up to 6% of global DALYs (10). The relationship between maternal and child weight and the consequences on disease incidence later in life have also been documented. For example, being overweight as a mother is associated with overweight and obesity in their offspring (2, 11). Rapid weight gain early in life may predispose to long-term excessive weight or obesity. And as the evidence suggests, obesity is an important underlying cause of many non-communicable diseases (NCDs), including hypertension, diabetes, cancer, stroke, and ischemic heart disease (3, 5, 11). These diseases are responsible for most of the deaths worldwide, with LMICs disproportionately bearing the brunt, where 80% of the NCD deaths occur (2-4). Experts warned that unless countries in Africa start enacting measures to tackle the DBM affecting the continent, the road towards universal health care (UHC) will be marred with obstacles as will the aspiration to achieve health and wellbeing for all by 2030 (12).

It is important to underscore that DBM can exist at the individual, household and population levels (2). For instance, at the individual level, obesity can occur with deficiency of one or various vitamins and minerals, or overweight in an adult who was stunted during childhood. At the household level, a mother may be overweight or anaemic and a child or grandparent is underweight. DBM at the population level occurs when there is a prevalence of both under- and over-nutrition in the same community, nation or region (2). Since it will be difficult to determine individual and within households DBM using these data, our definition of DBM is at population or country level, whereby underweight and overweight/obesity co-exist in the same country. Undoubtedly, the DBM offers an important opportunity for use of multidimensional approaches in tackling malnutrition in all its

forms. Addressing the DBM will be key to achieving the Sustainable Development Goals (in particular Goal 2 and Target 3.4) and the Commitments of the Rome Declaration on Nutrition, within the UN Decade of Action on Nutrition (1). However, as a starting point, countries need to understand the key correlates of DBM. The present paper attempts to elucidate these correlates.

The factors influencing DBM are complex; ranging from biological to environmental factors (2). Some of these factors may include, poor water and sanitation systems, weak public health systems thereby thwarting efforts to reduce undernutrition (2). Also, increasing urbanization and changing dietary patterns and sedentary lifestyles, income level, older age, household wealth, higher education, place of residence among others have been identified as key contributing factors to the DBM epidemic (13-16). For example, Kamal and colleagues observed in their study that household wealth index and place of residence are key predictors of the DBM among women in Bangladesh (17). Women from the poorest wealth quintile were more likely to suffer from DBM relative to those from the richest wealth quintile. Besides, marital status, age at first childbirth, parity, household size and food security were also found to play a critical role in the DBM epidemic (14, 17, 18). The above referenced studies used data from a single country, masking differences and commonalities of the effects of the correlates on DBM across countries. The present study is intended to fill this gap.

Given the anticipated long-term effects of DBM, the factors that are associated with being underweight, overweight or obese should be considered while formulating effective interventions

to address DBM among women (15, 16). This stresses the need for prevention strategies targeted at addressing all forms of malnutrition. The present study is well positioned to provide evidence on the key correlates of DBM in SSA, which is currently lacking in the region. Understanding the role of these risk factors is key to developing clear and effective strategies for improving public health in SSA. The overarching aim of our study is to examine the correlates of DBM among women in five SSA countries.

Methodology

Sources of data and sampling procedure

Design and data sources

The study used the recent Demographic and Health Surveys (DHS) (19) data from Ghana (2014), Kenya (2014), Nigeria (2013), Mozambique (2011) and Democratic Republic of Congo (DRC) (2013-2014). These are nationally representative, repeated cross-sectional household surveys collected primarily in lower- and middle-income countries approximately every 5 years and standardized to enable cross-country comparisons (20, 21). The design of the DHS surveys is identical across all participating countries, making possible the comparisons between and across countries. The DHS utilizes a two-stage sample design (22-26). The first stage involves the selection of sample points or clusters from an updated master sampling frame constructed from National Population and Housing Census of the respective countries. The clusters are selected using systematic sampling with probability proportional to size. Household listing is then conducted in all the selected clusters to provide a sampling frame for the second stage selection of households. The second stage of

selection involves the systematic sampling of the households listed in each cluster, and households to be included in the survey are randomly selected from the list. The rationale for the second stage selection is to ensure adequate numbers of completed individual interviews to provide estimates for key indicators with an acceptable precision. All men and women aged 15-59 and 15-49 respectively, in the selected households (men in half of the households) were eligible to participate in the surveys if they were either usual residents of the household or visitors present in the household on the night before the survey. We limited our analyses to women aged 15–49 years in all countries and who have complete anthropometry data. The samples for the respective countries are as follows: DRC (9,506), Ghana (3,012), Kenya (9,993), Mozambique (11,017) and Nigeria (31,170).

Ethics statement

The DHS obtained ethical clearance from the ethical committees of the respective countries before the surveys were conducted. Written informed consent was obtained from the women before participation. The authors of this paper sought and obtained permission from the DHS program for the use of the data. The data were completely anonymized and therefore the authors did not seek further ethical clearance before their use.

Patient and Public Involvement statement

We used completely anonymised secondary data for the analysis. Therefore, no patients or public involvement can be reported.

Outcome and predictor variables

Outcome variables: The outcome variable of interest was women body mass index (BMI) derived from results of height and weight measurements. The Height and weight were measured objectively by trained field technicians using standard techniques (21)**.** Weight measurements were taken using electronic Seca scales with a digital screen, while height measurements were taken using a stadiometer produced by Shorr Productions. BMI, also referred to as Quetelet's Index (27), was derived by dividing weight in kilograms by the squared height in meters. Based on the BMI (kg/m^2) estimates, and according to World Health Organization guidelines (28), the participants were classified as underweight (BMI<18.50 kg/m^2), normal weight (18.50-24.99 kg/m^2), overweight (25.0-29.9 kg/m^2) and obese (≥ 30.0 kg/m^2). The normal weight (18.50-24.99 kg/m^2) was used as reference category in the analysis.

Predictor variables: The predictor variables of interest used in the analysis included, women's age, education, employment status, breastfeeding status, parity, place of residence, marital status, women decision making autonomy (decision on large household purchases and decision on health), household size, frequency of watching TV and household wealth index. These potential correlates were identified based on literature search and further subjected to bivariate analysis to establish their relationship with the DBM indicators. All statistically significant variables were included in the multivariable analysis.

Analytical strategy

We utilized Multinomial logistic regression (MLR) in the analysis. MLR approach was contemplated to be suitable as the outcome measure is polychotomous by nature. Further, the MLR was considered attractive analytical technique because it does not assume normality, linearity, or homoscedasticity (29). In MLR, we observe vectors $Y = (y_1, y_2, \ldots, y_{k+1})^T$; $y_i = 0$ for all i, and one j with $y_j = 1$ and corresponding probability p_j, implying

$$EY = p,\ Cov\ Y = \Lambda_p - pp^T,\quad \Lambda_p = \begin{pmatrix} p_1 & \cdots & 0 \\ \vdots & \ddots & \vdots \\ 0 & \cdots & p_{k+1} \end{pmatrix} \tag{1}$$

The multinomial logistic regression is given by

$$p_i = \frac{\exp\,(\pi^{(i)^T} x)}{1 + \sum_{j=1}^{k} \exp\,(\pi^{(i)^T} x)} \quad \text{for i = 1, ..., k} \tag{2}$$

$$p_{k+1} = \frac{1}{1 + \sum_{j=1}^{k} \exp\,(\pi^{(i)^T} x)} \tag{3}$$

Where $x = (x_1, x_2, \ldots, x_m)^T$ is the vector of covariates, and $\pi^{(i)}$ is the parameter vector corresponding to the i-th response category. In Equation (3), the parameters are set to zero and allows computing the probability for the base category in the MLR.

Because of the normalization condition,

$$\sum_{j=1}^{k} P(y^{(j)} = 1 | x, \pi) = 1, \tag{4}$$

the weight vector of one of the classes need not to be estimated without loss of generality, in this case the $(j+1)$-th category. To perform maximum likelihood (ML), one simply maximizes the log-likelihood function using Equation (5),

$$log \prod_{j=1}^{k+1} p_j^{y_j} = \sum_{j=1}^{k} y_j \pi^{(i)^T} x - log\left[1 + \sum_{j=1}^{k} \exp\,(\pi^{(i)^T} x)\right] \tag{5}$$

The MLR model was constructed to investigate the net effects of the correlates on underweight, overweight, and obesity. Using a BMI category of 18.5–24.99 kg/m2 (normal weight) as the reference, a set of logistic regressions for underweight, overweight and obese categories was estimated in which, each of the categories was contrasted with the reference category. All covariates were simultaneously entered into the model. Results were presented in the form of coefficients with significance levels and 95% confidence intervals (95% CI).

Results

Descriptive

Tables 1 and 2 present the characteristics of the samples. The results in Table 1 show that among the five countries, Mozambique had the highest number of normal weight women (78%) followed by DRC (74%), with Ghana having the lowest (59%). Kenya (12%) and DRC (13%) had the highest prevalence of underweight women, while Ghana had the highest number of overweight (23%) and obese (12%) women. In all the countries analysed, the prevalence of overweight and obesity had overtaken underweight. In Table 2, women in Kenya had more years of education, while Mozambique had women with the least years of education. The age of study participants was similar across all the five countries and ranged from 28 years in Mozambique and Kenya to 30 years in Ghana. Further, among all the countries, Ghana had the highest number of women who were working (79%), while Mozambique had the lowest (39%).

Table 1: Characteristics of the BMI samples

Variables	DRC Mean/%	Ghana Mean/%	Kenya Mean/%	Mozambique Mean/%	Nigeria Mean/%
Body mass index (BMI)					
BMI=18.50-24.99 (normal weight)	73.50	59.20	62.00	77.60	66.10
BMI<18.50 (underweight)	12.70	5.30	11.80	5.70	8.70

BMI= 25-29.99 (overweight)	11.50	23.40	18.90	13.70	18.30
BMI>=30 (obesity)	2.30	12.20	7.30	3.00	7.00

Table 2: Characteristics of the samples, categorical and continuous variables

	DRC		Ghana		Kenya		Mozambique		Nigeria	
Variables	Mean/%	SD	Mean/%	SD	Mean/%	SD	Mean/%	SD	Mean/%	SD.
Women's Education (in years)	5.2	3.8	6.0	4.9	7.6	4.0	3.1	3.3	4.7	5.7
Women's Age (in years)	29.2	6.8	30.6	6.8	28.6	6.4	28.6	7.3	29.4	7.0
Household wealth index										
Poorest	22.4		22.7		23.4		23.6		23.5	
Poorer	23.0		19.8		20.3		21.4		23.1	
Middle	20.6		20.6		18.5		20.0		18.9	
Rich	18.6		18.7		18.2		19.9		17.8	
Richest	15.5		18.2		19.6		15.1		16.8	
Respondent currently working (yes)	74.9		78.8		63.6		39.3		68.9	
Place of residence (urban)	29.9		45.4		36.1		27.5		35.0	
Household head (Female)	21.6		26.0		30.4		30.3		9.7	
Parity	4.4	2.6	3.6	2.1	3.5	2.3	3.9	2.3	4.3	2.6
Household size	6.8	2.9	5.6	2.6	5.6	2.4	6.0	2.6	7.0	3.6
Frequency of watching TV										
Not at all	66.4		19.6		22.0		34.5		39.8	
Less than once a week	14.6		32.7		12.5		23.2		25.0	
At least once a week	19.0		47.7		65.5		42.3		35.2	
Currently breastfeeding (yes)	68.6		57.8		54.0		60.8		54.8	
Marital status										

Never Married	4.3	7.1	7.1	4.2	1.6
Married or Cohabiting	87.2	86.5	83.7	84.3	95.9
Formerly in union	8.5	6.4	9.2	11.5	2.6
Decision on large household purchases					
Respondent alone	8.7	20.8	29.1	17.2	4.7
Both Respondent and partner	31.0	42.7	34.2	39.1	29.2
Partner alone	47.3	22.2	20.1	27.5	61.6
Someone else/Other	0.2	0.9	0.4	0.6	0.2
Decision on respondent's health					
Respondent alone	13.8	16.3	14.7	10.0	4.3
Both Respondent and partner	37.2	44.8	42.2	38.2	28.4
Partner alone	35.6	24.4	26.3	35.4	62.8
Someone else/Other	0.3	1.0	0.4	0.7	0.2

SD=Standard deviation; DRC=Democratic Republic of Congo

Multivariable

Tables 3-7 present the MLR results of the correlates of DBM among women in DRC, Ghana, Kenya, Mozambique and Nigeria. The results showed a significant positive relationship between women's years' of education and overweight in Ghana, both overweight and obesity in Mozambique and Nigeria. Thus, compared with normal weight women, an additional year of education was associated with a higher likelihood of overweight and obesity in Ghana, Mozambique and Nigeria. Conversely, number of years of education was associated negatively with underweight in Kenya and Nigeria relative to normal weight. Also, older age was significantly and positively associated with underweight, overweight and obesity compared to normal weight women in all countries included in the analysis. An exception could be made of Nigeria where older age was inversely related to underweight. The results in relation to household wealth index were mixed. While generally, significant positive associations were observed between wealth index (middle, richer and richest quintiles) and overweight and obesity in all the five countries, inverse relationship was observed for underweight. Compared to normal weight women, higher maternal parity was inversely related to underweight in Ghana and Mozambique, and both underweight and overweight in Kenya. In DRC, maternal parity was inversely related to underweight and positively related to obesity. Breastfeeding was associated with less likelihood of underweight among women in DRC and Nigeria, obesity in DRC and Ghana, overweight in Kenya, and overweight and obesity in Mozambique and Nigeria relative to normal weight women.

Table 3: Multivariable analysis of the association between sociodemographic correlates and malnutrition, DRC

Variables	Underweight (BMI<18.50)	Overweight (BMI=25-29.99)	Obesity (BMI >=30)
Women's Education (in years)	0.030*	-0.011	-0.023
	(-0.004 - 0.064)	(-0.052 - 0.030)	(-0.093 - 0.047)
Women's Age (in years)	0.041***	0.034**	-0.045
	(0.015 - 0.068)	(0.007 - 0.060)	(-0.104 - 0.015)
Household wealth Index			
Poorest (reference)			
Poorer	-0.009	-0.069	-0.241
	(-0.306 - 0.288)	(-0.488 - 0.351)	(-1.575 - 1.094)
Middle	-0.144	0.421**	0.570
	(-0.534 - 0.247)	(0.039 - 0.804)	(-0.529 - 1.669)
Rich	-0.480**	0.803*	2.365***
	(-0.942 - -0.018)	(0.345 - 1.261)	(1.225 - 3.505)
Richest	-1.017***	1.486*	4.014***
	(-1.564 - -0.471)	(0.985 - 1.987)	(2.562 - 5.465)
Woman currently working (yes)	0.226	-0.462***	-0.350
	(-0.052 - 0.504)	(-0.794 - -0.131)	(-0.850 - 0.149)
Place of residence (urban)	-0.246	0.034	-0.094
	(-0.601 - 0.108)	(-0.350 - 0.417)	(-0.810 - 0.622)
Sex of household head (female)	-0.0453	0.167	0.363
	(-0.377 - 0.286)	(-0.144 - 0.478)	(-0.380 - 1.105)
Parity	-0.122***	0.0335	0.350***
	(-0.199 - -0.045)	(-0.040 - 0.107)	(0.174 - 0.525)
Household size	-0.019	-0.008	-0.052
	(-0.066 - 0.028)	(-0.048 - 0.031)	(-0.158 - 0.056)
Frequency of watching TV			
Not at all (reference)			
Less than once a week	0.089	0.165	-0.209
	(-0.251 - 0.429)	(-0.192 - 0.522)	(-0.912 - 0.494)
At least once a week	-0.163	0.180	0.149
	(-0.623 - 0.298)	(-0.140 - 0.500)	(-0.373 - 0.671)
Currently breastfeeding	0.327***	-0.010	-0.512**
	(0.082 - 0.572)	(-0.361 - 0.164)	(-1.020 - -0.005)
Marital status			
Never in union (reference)			
Married or Cohabiting	-0.766*	0.809*	0.248
	(-1.567 - 0.0347)	(0.132 - 1.486)	(-1.131 - 1.626)
Formerly in union	-0.357	0.0680	-0.549
	(-1.126 - 0.413)	(-0.583 - 0.718)	(-1.956 - 0.859)
Decision on large household purchases			
Respondent alone (reference)			
Both Respondent and partner	0.186	0.155	0.885*

	(-0.292 - 0.664)	(-0.291 - 0.601)	(-0.154 - 1.923)
Partner alone	0.436*	0.098	0.423
	(-0.059 - 0.931)	(-0.325 - 0.522)	(-0.370 - 1.215)
Someone else/Other	-0.787	-3.160***	-12.640***
	(-2.567 - 0.993)	(-5.513 - -0.808)	(-14.160 - -11.130)
Decision on respondent's health			
Respondent alone (reference)			
Both Respondent and partner	-0.180	-0.332	-0.743*
	(-0.599 - 0.239)	(-0.731 - 0.067)	(-1.594 - 0.109)
Partner alone	-0.176	-0.525**	-0.602*
	(-0.552 - 0.201)	(-0.933 - -0.116)	(-1.282 - 0.078)
Someone else/Other	1.672**	0.687	-14.200***
	(0.073 - 3.272)	(-1.990 - 3.363)	(-15.970 - -12.430)
Observations	9,506	9,506	9,506

Confidence Intervals (CI) in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Multivariable analysis of the association between sociodemographic correlates and malnutrition, Ghana

Variables	Underweight BMI<18.50	Overweight BMI=25-29.99	Obesity BMI>= 30
Women's Education (in years)	-0.022	0.074***	0.028
	(-0.080 - 0.036)	(0.037 - 0.110)	(-0.014 - 0.070)
Women's Age (in years)	0.054**	0.0405**	0.083***
	(0.005 - 0.103)	(0.008 - 0.073)	(0.048 - 0.118)
Household wealth index			
Poorest (reference)			
Poorer	-0.398	0.367	1.390***
	(-0.972 - 0.177)	(-0.129 - 0.864)	(0.582 - 2.197)
Middle	-1.050***	0.893*	2.804***
	(-1.768 - -0.331)	(0.340 - 1.447)	(1.947 - 3.662)
Rich	-0.529	1.436*	3.591***
	(-1.426 - 0.369)	(0.878 - 1.995)	(2.615 - 4.568)
Richest	-1.788***	1.271*	4.121***
	(-3.052 - -0.523)	(0.555 - 1.988)	(3.125 - 5.117)
Woman currently working (yes)	-0.125	0.121	0.0769
	(-0.713 - 0.463)	(-0.238 - 0.481)	(-0.424 - 0.577)
Place of residence (urban)	0.463*	0.113	-0.073
	(-0.0488 - 0.975)	(-0.250 - 0.477)	(-0.582 - 0.435)
Sex of household head (female)	0.409	0.0971	0.293
	(-0.276 - 1.093)	(-0.309 - 0.503)	(-0.173 - 0.759)
Parity	-0.205**	0.0719	0.0324
	(-0.372 - -0.038)	(-0.055 - 0.199)	(-0.118 - 0.183)
Household size	0.021	-0.047	0.035

	(-0.045 - 0.086)	(-0.121 - 0.027)	(-0.077 - 0.147)
Frequency of watching TV			
Not at all (reference)			
Less than once a week	-0.043	0.231	0.673*
	(-0.604 - 0.518)	(-0.240 - 0.703)	(0.0003 - 1.345)
At least once a week	-0.233	0.248	0.756**
	(-0.754 - 0.287)	(-0.184 - 0.679)	(0.146 - 1.365)
Currently breastfeeding (yes)	0.136	-0.177	-0.471**
	(-0.364 - 0.637)	(-0.525 - 0.171)	(-0.832 - -0.110)
Marital status			
Never in union (reference)			
Married or Cohabiting	-0.536	-0.259	0.295
	(-1.843 - 0.772)	(-0.904 - 0.386)	(-0.860 - 1.451)
Formerly in union	0.271	0.420	1.435*
	(-0.837 - 1.378)	(-0.286 - 1.126)	(0.400 - 2.470)
Decision on large household purchases			
Respondent alone (reference)			
Both Respondent and partner	0.464	-0.0143	-0.0496
	(-0.555 - 1.483)	(-0.523 - 0.495)	(-0.657 - 0.557)
Partner alone	0.664	-0.0223	-0.265
	(-0.217 - 1.546)	(-0.556 - 0.512)	(-0.917 - 0.386)
Someone else/Other	-1.212	-0.0290	0.752
	(-3.637 - 1.213)	(-1.485 - 1.426)	(-1.161 - 2.665)
Decision on respondent's health			
Respondent alone (reference)			
Both Respondent and partner	0.0525	0.785*	0.787*
	(-0.868 - 0.973)	(0.280 - 1.290)	(0.166 - 1.408)
Partner alone	0.119	0.526*	0.915*
	(-0.643 - 0.881)	(-0.0457 - 1.098)	(0.156 - 1.675)
Someone else/Other	-0.714	-1.544	-13.43***
	(-2.832 - 1.403)	(-3.520 - 0.433)	(-15.04 - -11.81)
Observations	3,012	3,012	3,012

Confident Intervals (CI) in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Multivariable analysis of the association between sociodemographic correlates and malnutrition, Kenya

Variables	Underweight (BMI<18.50)	Overweight (BMI=25.29.99)	Obesity (BMI>=30)
Women's Education (in years)	-0.113***	0.013	0.013
	(-0.148 - -0.078)	(-0.016 - 0.042)	(-0.030 - 0.056)

Women's Age (in years)	0.026**	0.066***	0.120***
	(0.001 - 0.052)	(0.046 - 0.089)	(0.087 - 0.153)
Household wealth index			
Poorest (reference)			
Poorer	-0.488***	0.279*	0.633*
	(-0.805 - -0.172)	(-0.025 - 0.582)	(0.080 - 1.187)
Middle	-0.500***	0.609***	0.790*
	(-0.869 - -0.130)	(0.261 - 0.957)	(0.268 - 1.311)
Rich	-0.940***	0.927*	1.690***
	(-1.376 - -0.504)	(0.578 - 1.276)	(1.164 - 2.216)
Richest	-1.307***	1.427***	2.616***
	(-1.946 - -0.668)	(1.042 - 1.813)	(2.049 - 3.184)
Woman currently working (yes)	-0.357***	0.0162	0.210
	(-0.590 - -0.123)	(-0.221 - 0.253)	(-0.110 - 0.529)
Place of residents (urban)	0.0337	0.107	0.497***
	(-0.272 - 0.339)	(-0.115 - 0.330)	(0.177 - 0.817)
Sex of household head (female)	0.230	0.0205	-0.0346
	(-0.0570 - 0.518)	(-0.177 - 0.218)	(-0.336 - 0.267)
Parity	-0.164***	-0.118***	-0.084
	(-0.243 - -0.085)	(-0.190 - -0.046)	(-0.199 - 0.030)
Household size	-0.035	0.013	0.034
	(-0.089 - 0.019)	(-0.034 - 0.061)	(-0.044 - 0.111)
Frequency of watching TV			
Not at all			
Less than once a week	-0.539***	0.076	-0.131
	(-0.905 - -0.174)	(-0.295 - 0.447)	(-0.700 - 0.439)
At least once a week	-0.066	0.043	0.035
	(-0.355 - 0.223)	(-0.194 - 0.281)	(-0.357 - 0.426)
Currently breastfeeding (yes)	0.102	-0.156*	-0.204
	(-0.112 - 0.316)	(-0.338 - 0.026)	(-0.510 - 0.102)
Marital status			
Never in union (reference)			
Married or Cohabiting	0.299	0.870*	0.898*
	(-0.197 - 0.794)	(0.422 - 1.317)	(0.212 - 1.584)
Formerly in union	0.209	0.488**	0.312
	(-0.339 - 0.756)	(0.047 - 0.929)	(-0.392 - 1.017)
Decision on household large purchases			
Respondent alone (reference)			
Both Respondent and partner	-0.217	-0.303**	0.0495
	(-0.546 - 0.113)	(-0.543 - -0.063)	(-0.259 - 0.358)
Partner alone	-0.298*	-0.0677	-0.128
	(-0.641 - 0.045)	(-0.350 - 0.215)	(-0.528 - 0.273)
Someone else/Other	-2.309***	-0.970	-13.66***
	(-4.053 - -0.565)	(-3.170 - 1.231)	(-14.580 - -12.730)
Decision on respondent's health			
Respondent alone (reference)			

Both Respondent and partner	-0.0559	0.0704	-0.131
	(-0.427 - 0.315)	(-0.194 - 0.335)	(-0.524 - 0.262)
Partner alone	-0.220	-0.016	-0.183
	(-0.601 - 0.161)	(-0.301 - 0.268)	(-0.633 - 0.266)
Someone else/Other	-2.446***	0.092	-12.920***
	(-4.226 - -0.666)	(-2.677 - 2.862)	(-14.610 - -11.230)
Observations	9,993	9,993	9,993

Confidence Intervals (CI) in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Multivariable analysis of the association between sociodemographic correlates and malnutrition, Mozambique

Variables	Underweight (BMI<18.50)	Overweight (BMI=25-29.99)	Obesity (BMI>=30)
Women's Education (yes)	0.011	0.044***	0.098***
	(-0.041 - 0.063)	(0.0127 - 0.076)	(0.041 - 0.156)
Women's Age (in years)	0.018	0.032***	0.075***
	(-0.013 - 0.049)	(0.012 - 0.052)	(0.042 - 0.109)
Household Wealth index			
Poorest (reference)			
Poorer	-0.146	0.618*	1.061
	(-0.479 - 0.187)	(0.222 - 1.015)	(-0.529 - 2.650)
Middle	-0.741***	0.856*	2.424***
	(-1.118 - -0.365)	(0.430 - 1.282)	(1.023 - 3.825)
Rich	-0.618***	1.235*	2.905***
	(-1.081 - -0.154)	(0.818 - 1.652)	(1.576 - 4.234)
Richest	-0.800***	1.977***	4.832***
	(-1.408 - -0.192)	(1.517 - 2.437)	(3.496 - 6.168)
Woman currently working (yes)	0.195	-0.0795	0.014
	(-0.087 - 0.477)	(-0.271 - 0.112)	(-0.371 - 0.400)
Place of residence (urban)	0.0766	-0.0722	-0.0180
	(-0.306 - 0.459)	(-0.350 - 0.205)	(-0.504 - 0.468)
Sex of household head (female)	-0.342**	-0.056	-0.142
	(-0.649 - -0.036)	(-0.264 - 0.153)	(-0.570 - 0.286)
Parity	-0.124**	0.0379	0.160**
	(-0.224 - -0.023)	(-0.024 - 0.100)	(0.037 - 0.282)
Household size	0.0161	-0.010	-0.037
	(-0.037 - 0.070)	(-0.042 - 0.022)	(-0.108 - 0.035)
Frequency of watching TV			
Not at all (reference)			
Less than once a week	-0.0113	0.157	0.630***
	(-0.328 - 0.306)	(-0.091 - 0.404)	(0.214 - 1.047)
At least once a week	-0.214	-0.0124	0.044
	(-0.518 - 0.0895)	(-0.213 - 0.188)	(-0.329 - 0.418)
Currently breastfeeding	0.215	-0.298***	-0.516**
	(-0.049 - 0.478)	(-0.493 - -0.102)	(-0.938 - -0.0944)

Marital status			
Never in union (reference)			
Married or Cohabiting	0.253	0.196	0.708*
	(-0.419 - 0.925)	(-0.223 - 0.615)	(-0.0469 - 1.462)
Formerly in union	0.351	-0.029	0.773**
	(-0.288 - 0.989)	(-0.462 - 0.404)	(0.0197 - 1.527)
Decision on large household purchases			
Respondent alone (reference)			
Both Respondent and partner	-0.096	-0.0634	-0.0414
	(-0.472 - 0.281)	(-0.329 - 0.202)	(-0.647 - 0.564)
Partner alone	-0.049	0.037	-0.366
	(-0.420 - 0.323)	(-0.256 - 0.329)	(-1.022 - 0.289)
Someone else/Other	0.036	0.746	-0.983
	(-1.044 - 1.115)	(-0.600 - 2.091)	(-3.268 - 1.303)
Decision on respondent's health			
Respondent alone (reference)			
Both Respondent and partner	-0.184	-0.134	-0.143
	(-0.633 - 0.265)	(-0.425 - 0.158)	(-0.777 - 0.491)
Partner alone	-0.317	-0.148	0.227
	(-0.786 - 0.151)	(-0.440 - 0.144)	(-0.360 - 0.814)
Someone else/Other	-0.480	-0.646	-1.232
	(-1.477 - 0.516)	(-1.649 - 0.357)	(-3.319 - 0.855)
Observations	11,017	11,017	11,017

Confidence Intervals (CI) in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Multivariable analysis of the association between sociodemographic correlates and malnutrition, Nigeria

Variable	Underweight (BMI<18.50)	Overweight (BMI=25-29.99)	Obesity (BMI>=30)
Women's Education (in years)	-0.042***	0.034***	0.048***
	(-0.067 - -0.018)	(0.019 - 0.049)	(0.028 - 0.068)
Women's Age (in years)	-0.019**	0.040***	0.072***
	(-0.035 - -0.0021)	(0.030 - 0.051)	(0.056 - 0.088)
Household wealth index			
Poorest (reference)			
Poorer	-0.200**	0.289***	0.208
	(-0.366 - -0.034)	(0.090 - 0.488)	(-0.280 - 0.697)
Middle	-0.291**	0.691***	0.788*
	(-0.517 - -0.0650)	(0.479 - 0.903)	(0.298 - 1.278)
Rich	-0.208	0.998*	1.196*
	(-0.477 - 0.0614)	(0.764 - 1.232)	(0.694 - 1.698)
Richest	-0.530***	1.351***	1.862***
	(-0.921 - -0.139)	(1.074 - 1.628)	(1.353 - 2.372)

Woman currently working (yes)	-0.0518	0.0231	-0.292***
	(-0.198 - 0.0944)	(-0.102 - 0.148)	(-0.497 - -0.0878)
Place of residence (urban)	0.166	0.0775	0.178*
	(-0.0500 - 0.381)	(-0.0643 - 0.219)	(-0.0244 - 0.379)
Sex of household head (female)	-0.0836	0.0127	-0.084
	(-0.336 - 0.169)	(-0.149 - 0.174)	(-0.300 - 0.133)
Parity	-0.011	0.039**	0.0230
	(-0.0538 - 0.0313)	(0.009 - 0.0698)	(-0.021 - 0.067)
Household size	0.007	-0.009	0.023*
	(-0.015 - 0.029)	(-0.025 - 0.00654)	(-0.002 - 0.047)
Frequency of watching TV			
Not at all (reference)			
Less than once a week	-0.146	0.0771	0.0585
	(-0.336 - 0.045)	(-0.056 - 0.210)	(-0.162 - 0.278)
At least once a week	-0.252***	0.155**	0.205*
	(-0.438 - -0.066)	(0.024 - 0.285)	(-0.009 - 0.420)
Currently breastfeeding	0.178***	-0.176***	-0.363***
	(0.043 - 0.314)	(-0.278 - -0.073)	(-0.524 - -0.202)
Marital status			
Never in union			
Married or Cohabiting	-0.177	0.633*	0.557*
	(-0.652 - 0.299)	(0.188 - 1.078)	(-0.090 - 1.204)
Formerly in union	0.0721	0.921*	1.071*
	(-0.400 - 0.545)	(0.426 - 1.416)	(0.417 - 1.724)
Decision on large household purchases			
Respondent alone			
Both Respondent and partner	-0.206	0.0218	0.341*
	(-0.641 - 0.230)	(-0.209 - 0.252)	(-0.002 - 0.684)
Partner alone	-0.181	-0.015	-0.177
	(-0.579 - 0.218)	(-0.238 - 0.209)	(-0.538 - 0.184)
Someone else/Other	1.314*	-0.651	-0.225
	(-0.239 - 2.866)	(-1.912 - 0.609)	(-1.731 - 1.281)
Decision on respondent's health			
Respondent alone (reference)			
Both Respondent and partner	-0.0847	-0.0141	-0.192
	(-0.525 - 0.356)	(-0.251 - 0.223)	(-0.547 - 0.163)
Partner alone	0.069	0.025	-0.088
	(-0.334 - 0.474)	(-0.206 - 0.256)	(-0.460 - 0.283)
Someone else/Other	-2.381***	-1.369**	-2.604**
	(-1.417 - -0.423)	(-4.688 - -3.669)	(-7.160 - -5.311)
Observations	31,170	31,170	31,170

Confidence Intervals (CI) in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The figures 1 and 2 are pictorial presentations of the probability of women falling into underweight, overweight and obese categories if there were changes in their age and years of education.

Figure 1: Graphical Illustration of the results of the probability of falling into the DBM categories when years of education increase

Figure 2: Graphical Illustration of results of the probability of falling into the DBM categories when age increases

Discussion

This study investigated the correlates of DBM among women in five sub-Saharan African (SSA) countries. The key indicators of DBM used in the analysis were, underweight, overweight and obesity. The results showed expectedly that there are some variations across countries on how the correlates included in this study are associated with DBM. Our analysis reveals that in Ghana, Mozambique and Nigeria, a higher number of years of formal education is associated with the likelihood of overweight and obesity relative to normal weight women. Thus, a higher number of years of education is a risk factor for women with unhealthy weight. This could be due to lifestyles changes as one achieve more years of education, which may include sedentary lifestyles and poor dietary patterns (30). Further, it could be that people who are already overweight or obese have higher propensity of adding more weight relative to those who have normal weight. In contrast, there was an inverse relationship between the number of years of formal education and underweight in Kenya and Nigeria. These findings are in line with previous studies. In Ghana, higher

education was associated with overweight and obesity among women (31). Additionally, high education was associated positively with overweight among women in Indonesia (32). Nevertheless, in the same study, high education was associated with reduced risk of being underweight by 10–30% (32). This is contrary to our findings in Kenya and Nigeria.

Furthermore, age was associated positively with all the DBM indicators across the five countries. Thus, older women are more likely to be overweight and obese and less likely to be underweight. This suggests that older age is a protective factor for underweight, while a risk factor for overweight and obesity. This positive correlation between age, and overweight and obesity, may have a consequential effect on non-communicable diseases (NCDs) among older people, as an unhealthy weight is a major risk factor for NCDs (33-36). An exception to these findings could be made of Nigeria where older age was associated negatively with underweight women. This implies that in this setting, the older women become the more likelihood that they will suffer from underweight. The consequential effect of this may be poor health outcomes, as being underweight exposes women to higher risks of morbidity and mortality during pregnancy and child birth (37-39). The relationship between age and DBM has been documented in previous studies. For example, Doku and Neupane observed a significant positive association between age and the key indicators of DBM in Ghana (31). A study in Bangladesh observed a significant positive relationship between older age and DBM (40). These findings together with the findings from our study confirmed the contribution of age to the DBM epidemic.

Our analysis showed that household wealth index had mixed effects on DBM. In general, the three rich quintiles: middle, richer and richest were associated significantly and positively with overweight and obesity among women across all the countries included in the analysis. This may be due to obesogenic effects of increased household wealth as dietary pattern changes (41), and the fact that there is a documented positive correlation between household wealth and unhealthy body weight (42, 43). In Bangladesh and Nepal, higher household wealth was associated with an increased likelihood of being overweight and obese (42). Also, being rich was associated with overweight and obesity among Ghanaian women (31). Interestingly, higher household wealth had an inverse effect on underweight. This inverse relationship may be due to the fact that most underweight women are likely to be in the poorer wealth quintiles (44) and therefore, may be unaffected by the higher household wealth quintiles. The inverse relationship has been observed previously (45). Relatedly, compared to the richest, women from the poorest households were significantly most likely to be underweight and least likely to be overweight over normal weight in Bangladesh (17). Suggesting that being in the poorest household is protective against overweight but not underweight (44).

The health benefits of breastfeeding were illuminated in this study. Breastfeeding was found to associate with less likelihood of underweight, overweight and obesity in the five countries analysed. This suggests that mothers who have unhealthy weight should be encourage to practice breastfeeding as the benefits are not only to their offspring but also for their own health and wellbeing. These findings confirm the widely recognized benefits of breastfeeding for improved health and developmental outcomes in mothers and their infants (46-49). The implication of this

may be that interventions to promote breastfeeding may have positive impact on the DBM epidemic at the national level. The benefits of breastfeeding to women health have previously been documented. For example, breastfeeding has been suggested as an efficient means of promoting postpartum weight loss due to its high energy cost (50). Further evidence suggest that at 12 weeks postpartum, exclusively breastfeeding (EBF) mothers had lost more total body weight than mixed feeding mothers. However, mixed feeding mothers lost slightly more percent body fat than exclusively breastfeeding mothers (50).The authors concluded that EBF promotes greater weight loss than mixed feeding among mothers even in the early postpartum period. Several other studies have shown that EBF influences postpartum weight loss (49-52). The preceding discussion points to the need for health policy makers to design programmes to encourage mothers to breastfeed, especially, practice exclusive breastfeeding as a means of DBM prevention.

An important strength of our study is the use of large nationally representative samples, thereby providing more robust estimates of observed associations as well as enhancing the generalizability of the findings. The use of multi-country data help unmask differences and commonalities in the effects of the correlates on DBM across countries, which would not have been possible with single country data. Additionally, the height and weight data which were used to compute the BMI were objectively measured, reducing possible misclassification. A limitation worth mentioning is the cross-sectional nature of the data, which does not lends itself to the establishments of causal relationship between the predictor and outcome variables. The conclusions in the paper are therefore interpreted as mere associations between the predictor variables and the outcome variable. Another limitation is that due to data limitation, we were not able to examine DBM at the

individual and within households. The analysis and interpretation in this paper are therefore limited to DBM at population or national level, whereby underweight, overweight and obesity co-exist in the same country.

Conclusions

The study investigated the correlates of the DBM in five SSA countries. The analysis revealed that the effects of the correlates on DBM are largely similar across countries, except in few cases where there were disparities in the effects. The results indicate that higher number of years of education increases the likelihood of overweight and obesity among women in Ghana, Mozambique and Nigeria. Conversely, number of years of education is associated negatively with underweight in Kenya and Nigeria. Living in better-off households increases significantly the likelihood of overweight and obesity among women across all countries, while associated with the likelihood of underweight. Interventions to address DBM should take into account socioeconomic status. This may include providing special programmes for women who have unhealthy weight in wealthy households. A unit change in age is also associated significantly and positively with underweight, overweight and obesity in all the countries included in the analysis. Breastfeeding is associated with least likelihood of underweight, overweight and obesity in breastfeeding mothers. This implies that interventions to prevent DBM should incorporate breastfeeding to enhance their effectiveness.

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Competing Interest

The authors have no competing interests to declare.

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Data Sharing Statement

This study was a re-analysis of existing data that are publicly available from The DHS Program at http://dhsprogram.com/publications/publication-fr221-dhs-final-reports.cfm. Data are accessible free of charge upon a registration with the Demographic and Health Survey program (The DHS Program). The registration is done on the DHS website indicated above.

Authors' Contribution

DAA conceived and designed the study. DAA and ZTD conducted the data analysis, interpreted the results and drafted the manuscript. CK contributed to study design, data analysis, interpretation, and critical revision of the manuscript. All authors take responsibility of any issues that might arise from the publication of this manuscript.

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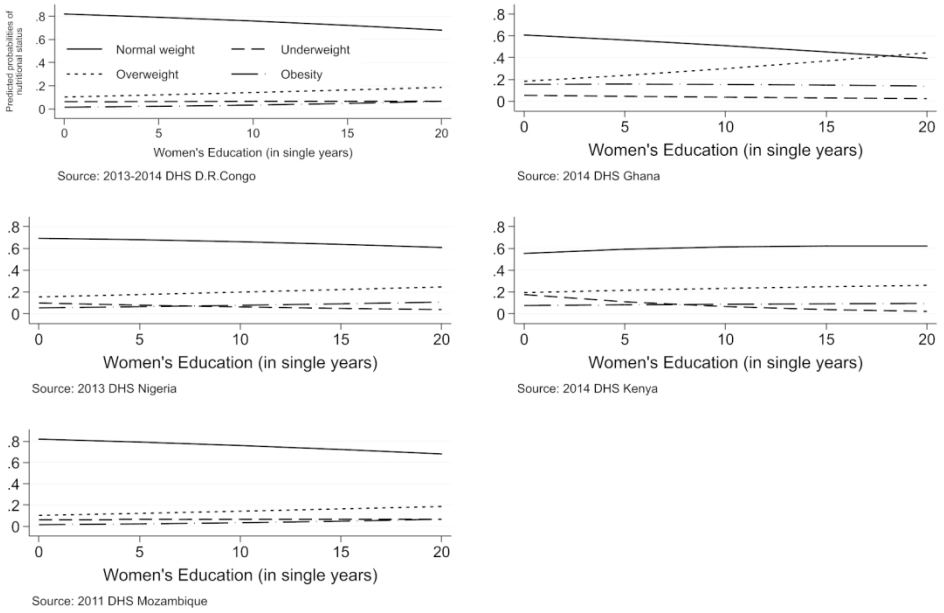

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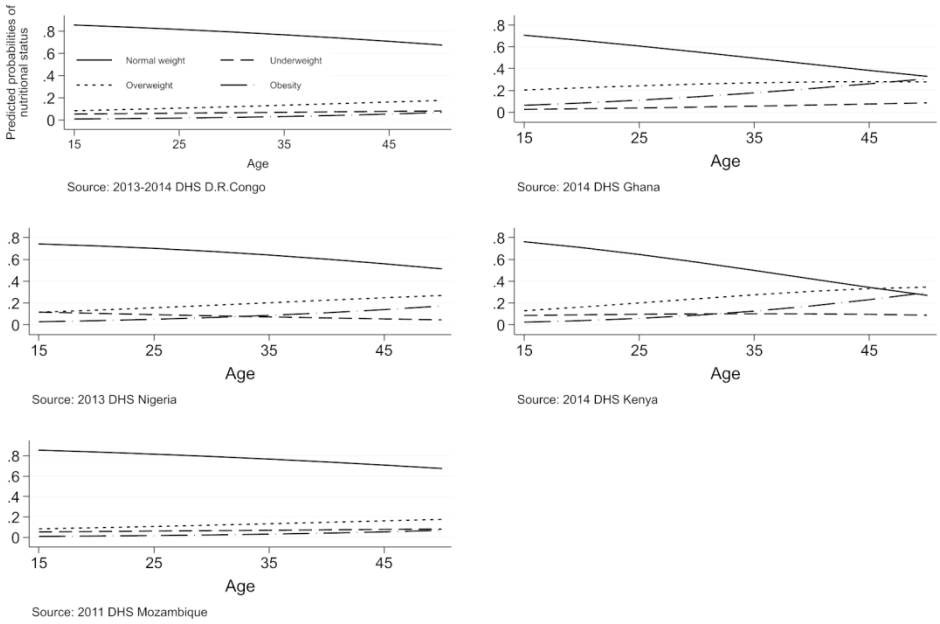

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6-
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	7-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-9
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9-10
		(*b*) Describe any methods used to examine subgroups and interactions	9-10
		(*c*) Explain how missing data were addressed	9-10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	NA
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-12
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	NA
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-10
		(*b*) Report category boundaries when continuous variables were categorized	10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	21
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	24
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	21-24
Generalisability	21	Discuss the generalisability (external validity) of the study results	25
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	NA

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Correlates of the double burden of malnutrition among women: an analysis of cross sectional survey data from sub-Saharan Africa

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Abstract

Objective: To investigate the correlates of the double burden of malnutrition (DBM) among women in five sub-Saharan African countries

Design: Secondary analysis of Demographic and Health Surveys (DHS). The outcome variable was body mass index (BMI), a measure of DBM. The BMI was classified into underweight (BMI<18.50 kg/m^2), normal weight (18.50-24.99 kg/m^2), overweight (25.0-29.9 kg/m^2) and obesity (≥ 30.0 kg/m^2).

Settings: Ghana, Nigeria, Kenya, Mozambique and Democratic Republic of Congo (DRC).

Subjects: Women aged 15-49 years (*n* 64,698).

Results: Compared with normal weight women, number of years of formal education was associated with the likelihood of being overweight and obese in Ghana, Mozambique and Nigeria, while associated with the likelihood of being underweight in Kenya and Nigeria. Older age was associated with the likelihood of being underweight, overweight and obese in all countries. Positive associations were also observed between living in better-off households, and overweight and obesity, while a negative association was observed for underweight. Breastfeeding was associated with less likelihood of underweight in DRC and Nigeria, obesity in DRC and Ghana, overweight in Kenya, and overweight and obesity in Mozambique and Nigeria relative to normal weight.

Conclusions: Our analysis reveals that in all the countries, women who are breastfeeding are less likely to be underweight, overweight and obese. Education, age and household wealth index tend to associate with a higher likelihood of DBM among women. Interventions to address DBM should take into account the variations in the effects of these correlates.

Keyword: Double burden, malnutrition, women, correlates, sub-Saharan Africa

Strengths and limitations of this study

- Large nationally representative samples used, thereby providing more robust estimates of observed associations
- The height and weight data used to compute the BMI were objectively measured, reducing possible misclassification
- Use of multi-country data helped unmask differences and commonalities in the effects of the correlates on DBM across countries
- The use of cross-sectional surveys may not allow to establish causation
- Due to data limitation, the DBM was examined only at the population or national level

Introduction

The Double Burden of Malnutrition (DBM), which is the coexistence of both undernutrition and over-nutrition in the same population across the life course is a global public health problem (1, 2). Data from the World Health Organization (WHO) indicate that in 2014, 1.9 billion adults aged 18 years and above were overweight, while over 600 million were obese globally (1). Similarly, in the same year, 462 million adults were underweight and 264 million women of reproductive age were affected by iron-amenable anaemia (2, 3). These key indicators of DBM are also increasing globally, with the low and middle income countries (LMICs) being the most affected (4). For example, while globally, obesity has doubled in the last three decades, it has tripled in LMICs in just two decades (5). An analysis of survey data from 24 African countries spanning 25 years, revealed that overweight and obesity among women are on the rise (6). Also, comparative analysis of data on women and men in the developing countries showed that DBM tends to disproportionately affect women than men (7, 8). The vulnerability of women to DBM may be attributed to their high nutritional requirements for pregnancy and lactation and also because of gender inequalities in poverty (8). Further evidence suggests that if micronutrient deficiencies are taken into account, Africa is in fact experiencing a triple burden of malnutrition (2, 3). It has been estimated that almost 50 percent of pregnant women in Africa suffer from anaemia, which increases the risk of death for themselves as well as their unborn babies (2).

Furthermore, the contribution of DBM to the burden of disease has been documented. The available evidence suggests that underweight and obesity are among the top ten leading risk factors for the global burden of disease (9, 10). Furthermore, more recent WHO data have

identified underweight among the top four risks factors for the burden of disease in the world, as measured in disability-adjusted life years (DALYs)—contributing up to 6% of global DALYs (10). The relationship between maternal and child weight and the consequences on disease incidence later in life have also been documented. For example, being overweight as a mother is associated with overweight and obesity in their offspring (2, 11). Rapid weight gain early in life may predispose to long-term excessive weight or obesity. And as the evidence suggests, obesity is an important underlying cause of many non-communicable diseases (NCDs), including hypertension, diabetes, cancer, stroke, and ischemic heart disease (3, 5, 11). These diseases are responsible for most of the deaths worldwide, with LMICs disproportionately bearing the brunt, where 80% of the NCD deaths occur (2-4). Experts warned that unless countries in Africa start enacting measures to tackle the DBM affecting the continent, the road towards universal health care (UHC) will be marred with obstacles as will the aspiration to achieve health and wellbeing for all by 2030 (12).

It is important to underscore that DBM can exist at the individual, household and population levels (2). For instance, at the individual level, obesity can occur with deficiency of one or various vitamins and minerals, or overweight in an adult who was stunted during childhood. At the household level, a mother may be overweight or anaemic and a child or grandparent is underweight. DBM at the population level occurs when there is a prevalence of both under- and over-nutrition in the same community, nation or region (2). Since it will be difficult to determine individual and within households DBM using these data, our definition of DBM is at population or country level, whereby underweight and overweight/obesity co-exist in the same country. Undoubtedly, the DBM offers an important opportunity for use of multidimensional approaches in tackling malnutrition in all its

forms. Addressing the DBM will be key to achieving the Sustainable Development Goals (in particular Goal 2 and Target 3.4) and the Commitments of the Rome Declaration on Nutrition, within the UN Decade of Action on Nutrition (1). However, as a starting point, countries need to understand the key correlates of DBM. The present paper attempts to elucidate these correlates.

The factors influencing DBM are complex; ranging from biological to environmental factors (2). Some of these factors may include, poor water and sanitation systems, weak public health systems thereby thwarting efforts to reduce undernutrition (2). Also, increasing urbanization and changing dietary patterns and sedentary lifestyles, income level, older age, household wealth, higher education, place of residence among others have been identified as key contributing factors to the DBM epidemic (13-16). For example, Kamal and colleagues observed in their study that household wealth index and place of residence are key predictors of the DBM among women in Bangladesh (17). Women from the poorest wealth quintile were more likely to suffer from DBM relative to those from the richest wealth quintile. Besides, marital status, age at first childbirth, parity, household size and food security were also found to play a critical role in the DBM epidemic (14, 17, 18). The above referenced studies used data from a single country, masking differences and commonalities of the effects of the correlates on DBM across countries. Suffice to add that Neupane and colleagues (19) attempted to investigate the problem of DBM using datasets from 32 sub-Saharan African (SSA) countries. This study however fell short of addressing DBM as it focused only on overweight and obesity. Secondly, the referenced study used only three variables (wealth quintile, place of residence and education) to predict overweight and obesity. The present study filled these gaps by simultaneously analysing underweight, overweight and obesity, using a

comprehensive list of predictor variables, to provide a robust picture of the correlates of DBM in SSA.

Given the anticipated long-term effects of DBM, the factors that are associated with being underweight, overweight or obese should be considered while formulating effective interventions to address DBM among women (15, 16). This stresses the need for prevention strategies targeted at addressing all forms of malnutrition. The present study is well positioned to provide evidence on the key correlates of DBM in SSA, which is currently lacking in the region. Understanding the role of these risk factors is key to developing clear and effective strategies for improving public health in SSA. The overarching aim of our study is to examine the correlates of DBM among women in five SSA countries.

Methodology

Sources of data and sampling procedure

Design and data sources

The study used the recent Demographic and Health Surveys (DHS) (20) data from Ghana (2014), Kenya (2014), Nigeria (2013), Mozambique (2011) and Democratic Republic of Congo (DRC) (2013-2014). The selection of these five countries was informed by our previous analysis (21). The DHS data are nationally representative, repeated cross-sectional household surveys collected primarily in lower- and middle-income countries approximately every 5 years, using standardized

questionnaires to enable cross-country comparisons (22, 23). The design of the DHS surveys is identical across all participating countries, making possible the comparisons between and across countries. The DHS utilizes a two-stage sample design (24-28). The first stage involves the selection of sample points or clusters from an updated master sampling frame constructed from National Population and Housing Census of the respective countries. The clusters are selected using systematic sampling with probability proportional to size. Household listing is then conducted in all the selected clusters to provide a sampling frame for the second stage selection of households. The second stage of selection involves the systematic sampling of the households listed in each cluster, and households to be included in the survey are randomly selected from the list. The rationale for the second stage selection is to ensure adequate numbers of completed individual interviews to provide estimates for key indicators with an acceptable precision. All men and women aged 15-59 and 15-49 respectively, in the selected households (men in half of the households) were eligible to participate in the surveys if they were either usual residents of the household or visitors present in the household on the night before the survey. We limited our analyses to women aged 15–49 years in all countries and who have complete anthropometry data. The samples for the respective countries are as follows: DRC (9,506), Ghana (3,012), Kenya (9,993), Mozambique (11,017) and Nigeria (31,170).

Ethics statement

The DHS obtained ethical clearance from Government recognised Ethical Review Committees/Institutional Review Boards of the respective countries as well as the Institutional Review Board of ICF International, USA, before the surveys were conducted. Written informed consent was obtained from the women before participation. The authors of this paper sought and

obtained permission from the DHS program for the use of the data. The data were completely anonymized and therefore the authors did not seek further ethical clearance before their use.

Patient and Public Involvement statement

We used completely anonymised secondary data for the analysis. Therefore, no patients or public involvement can be reported.

Outcome and predictor variables

Outcome variables: The outcome variable of interest was women body mass index (BMI) derived from results of height and weight measurements. The height and weight were measured objectively by trained field technicians using standard techniques (23)**.** Weight measurements were taken using electronic Seca scales with a digital screen, while height measurements were taken using a stadiometer produced by Shorr Productions. BMI, also referred to as Quetelet's Index (29), was derived by dividing weight in kilograms by the squared height in meters. Based on the BMI (kg/m^2) estimates, and according to World Health Organization guidelines (30), the participants were classified as underweight (BMI<18.50 kg/m^2), normal weight (18.50-24.99 kg/m^2), overweight (25.0-29.9 kg/m^2) and obese (≥ 30.0 kg/m^2). The normal weight (18.50-24.99 kg/m^2) was used as reference category in the analysis.

Predictor variables: The predictor variables of interest used in the analysis included, women's age, education, employment status, breastfeeding status, parity, place of residence, marital status,

women decision making autonomy (decision on large household purchases and decision on health), household size, frequency of watching TV and household wealth index. These potential correlates were identified based on literature search and further subjected to bivariate analysis to establish their relationship with the DBM indicators. All statistically significant variables were included in the multivariable analysis.

Analytical strategy

We utilized Multinomial logistic regression (MLR) in the analysis. MLR approach was contemplated to be suitable as the outcome measure is polychotomous by nature. Further, the MLR was considered attractive analytical technique because it does not assume normality, linearity, or homoscedasticity (31). In MLR, we observe vectors $Y = (y_1, y_2,\ldots, y_{k+1})^T$; $y_i = 0$ for all i, and one j with $y_j = 1$ and corresponding probability p_j, implying

$$EY = p,\ Cov\ Y = \Lambda_p - pp^T,\quad \Lambda_p = \begin{pmatrix} p_1 & \cdots & 0 \\ \vdots & \ldots & \vdots \\ 0 & \cdots & p_{k+1} \end{pmatrix} \qquad (1)$$

The multinomial logistic regression is given by

$$p_i = \frac{\exp\left(\pi^{(i)^T} x\right)}{1 + \sum_{j=1}^{k} \exp\left(\pi^{(i)^T} x\right)} \text{ for i = 1, ..., k} \qquad (2)$$

$$p_{k+1} = \frac{1}{1 + \sum_{j=1}^{k} \exp\left(\pi^{(i)^T} x\right)} \qquad (3)$$

Where $x = (x_1, x_2,\ldots, x_m)^T$ is the vector of covariates, and $\pi^{(i)}$ is the parameter vector corresponding to the i-th response category. In Equation (3), the parameters are set to zero and allows computing the probability for the base category in the MLR.

Because of the normalization condition,

$$\sum_{j=1}^{k} P(y^{(j)} = 1 | x, \pi) = 1, \quad (4)$$

the weight vector of one of the classes need not to be estimated without loss of generality, in this case the *(j+1)*-th category. To perform maximum likelihood (ML), one simply maximizes the log-likelihood function using Equation (5),

$$log \prod_{j=1}^{k+1} p_j^{y_j} = \sum_{j=1}^{k} y_j \pi^{(i)^T} x - log\left[1 + \sum_{j=1}^{k} \exp\left(\pi^{(i)^T} x\right)\right] \quad (5)$$

The MLR model was constructed to investigate the net effects of the correlates on underweight, overweight, and obesity. Using a BMI category of 18.5–24.99 kg/m2 (normal weight) as the reference, a set of logistic regressions for underweight, overweight and obese categories was estimated in which, each of the categories was contrasted with the reference category. All covariates were simultaneously entered into the model. Results were presented in the form of coefficients with significance levels and 95% confidence intervals (95% CI).

Results

Descriptive

Tables 1 and 2 present the characteristics of the samples. The results in Table 1 show that among the five countries, Mozambique had the highest number of normal weight women (78%) followed by DRC (74%), with Ghana having the lowest (59%). Kenya (12%) and DRC (13%) had the highest prevalence of underweight women, while Ghana had the highest number of overweight (23%) and obese (12%) women. In all the countries analysed, the prevalence of overweight and obesity had overtaken underweight. In Table 2, women in Kenya had more years of education, while Mozambique had women with the least years of education. The age of study participants was

similar across all the five countries and ranged from 28 years in Mozambique and Kenya to 30 years in Ghana. Further, among all the countries, Ghana had the highest number of women who were working (79%), while Mozambique had the lowest (39%).

Table 1: Characteristics of the BMI samples

Variables	DRC Mean/%	Ghana Mean/%	Kenya Mean/%	Mozambique Mean/%	Nigeria Mean/%
Body mass index (BMI)					
BMI=18.50-24.99 (normal weight)	73.50	59.20	62.00	77.60	66.10
BMI<18.50 (underweight)	12.70	5.30	11.80	5.70	8.70
BMI= 25-29.99 (overweight)	11.50	23.40	18.90	13.70	18.30
BMI>=30 (obesity)	2.30	12.20	7.30	3.00	7.00

Table 2: Characteristics of the samples, categorical and continuous variables

	DRC		Ghana		Kenya		Mozambique		Nigeria	
Variables	Mean/%	SD	Mean/%	SD	Mean/%	SD	Mean/%	SD	Mean/%	SD.
Women's Education (in years)	5.2	3.8	6.0	4.9	7.6	4.0	3.1	3.3	4.7	5.7
Women's Age (in years)	29.2	6.8	30.6	6.8	28.6	6.4	28.6	7.3	29.4	7.0
Household wealth index										
Poorest	22.4		22.7		23.4		23.6		23.5	
Poorer	23.0		19.8		20.3		21.4		23.1	
Middle	20.6		20.6		18.5		20.0		18.9	
Rich	18.6		18.7		18.2		19.9		17.8	
Richest	15.5		18.2		19.6		15.1		16.8	
Respondent currently working (yes)	74.9		78.8		63.6		39.3		68.9	
Place of residence (urban)	29.9		45.4		36.1		27.5		35.0	
Household head (Female)	21.6		26.0		30.4		30.3		9.7	
Parity	4.4	2.6	3.6	2.1	3.5	2.3	3.9	2.3	4.3	2.6
Household size	6.8	2.9	5.6	2.6	5.6	2.4	6.0	2.6	7.0	3.6
Frequency of watching TV										
Not at all	66.4		19.6		22.0		34.5		39.8	
Less than once a week	14.6		32.7		12.5		23.2		25.0	
At least once a week	19.0		47.7		65.5		42.3		35.2	
Currently breastfeeding (yes)	68.6		57.8		54.0		60.8		54.8	
Marital status										

Never Married	4.3	7.1	7.1	4.2	1.6
Married or Cohabiting	87.2	86.5	83.7	84.3	95.9
Formerly in union	8.5	6.4	9.2	11.5	2.6
Decision on large household purchases					
Respondent alone	8.7	20.8	29.1	17.2	4.7
Both Respondent and partner	31.0	42.7	34.2	39.1	29.2
Partner alone	47.3	22.2	20.1	27.5	61.6
Someone else/Other	0.2	0.9	0.4	0.6	0.2
Decision on respondent's health					
Respondent alone	13.8	16.3	14.7	10.0	4.3
Both Respondent and partner	37.2	44.8	42.2	38.2	28.4
Partner alone	35.6	24.4	26.3	35.4	62.8
Someone else/Other	0.3	1.0	0.4	0.7	0.2

SD=Standard deviation; DRC=Democratic Republic of Congo

Multivariable

Tables 3-7 present the MLR results of the correlates of DBM among women in DRC, Ghana, Kenya, Mozambique and Nigeria. The results showed a significant positive relationship between women's years' of education and overweight in Ghana, both overweight and obesity in Mozambique and Nigeria. Thus, compared with normal weight women, an additional year of education was associated with a higher likelihood of overweight and obesity in Ghana, Mozambique and Nigeria. Conversely, number of years of education was associated negatively with underweight in Kenya and Nigeria relative to normal weight. Also, older age was significantly and positively associated with underweight, overweight and obesity compared to normal weight women in all countries included in the analysis. An exception could be made of Nigeria where older age was inversely related to underweight. The results in relation to household wealth index were mixed. While generally, significant positive associations were observed between wealth index (middle, richer and richest quintiles) and overweight and obesity in all the five countries, inverse relationship was observed for underweight. Compared to normal weight women, higher maternal parity was inversely related to underweight in Ghana and Mozambique, and both underweight and overweight in Kenya. In DRC, maternal parity was inversely related to underweight and positively related to obesity. Breastfeeding was associated with less likelihood of underweight among women in DRC and Nigeria, obesity in DRC and Ghana, overweight in Kenya, and overweight and obesity in Mozambique and Nigeria relative to normal weight women.

Table 3: Multivariable analysis of the association between sociodemographic correlates and malnutrition, DRC

Variables	Underweight (BMI<18.50)	Overweight (BMI=25-29.99)	Obesity (BMI >=30)
Women's Education (in years)	0.030*	-0.011	-0.023
	(-0.004 - 0.064)	(-0.052 - 0.030)	(-0.093 - 0.047)
Women's Age (in years)	0.041***	0.034**	-0.045
	(0.015 - 0.068)	(0.007 - 0.060)	(-0.104 - 0.015)
Household wealth Index			
Poorest (reference)			
Poorer	-0.009	-0.069	-0.241
	(-0.306 - 0.288)	(-0.488 - 0.351)	(-1.575 - 1.094)
Middle	-0.144	0.421**	0.570
	(-0.534 - 0.247)	(0.039 - 0.804)	(-0.529 - 1.669)
Rich	-0.480**	0.803*	2.365***
	(-0.942 - -0.018)	(0.345 - 1.261)	(1.225 - 3.505)
Richest	-1.017***	1.486*	4.014***
	(-1.564 - -0.471)	(0.985 - 1.987)	(2.562 - 5.465)
Woman currently working (yes)	0.226	-0.462***	-0.350
	(-0.052 - 0.504)	(-0.794 - -0.131)	(-0.850 - 0.149)
Place of residence (urban)	-0.246	0.034	-0.094
	(-0.601 - 0.108)	(-0.350 - 0.417)	(-0.810 - 0.622)
Sex of household head (female)	-0.0453	0.167	0.363
	(-0.377 - 0.286)	(-0.144 - 0.478)	(-0.380 - 1.105)
Parity	-0.122***	0.0335	0.350***
	(-0.199 - -0.045)	(-0.040 - 0.107)	(0.174 - 0.525)
Household size	-0.019	-0.008	-0.052
	(-0.066 - 0.028)	(-0.048 - 0.031)	(-0.158 - 0.056)
Frequency of watching TV			
Not at all (reference)			
Less than once a week	0.089	0.165	-0.209
	(-0.251 - 0.429)	(-0.192 - 0.522)	(-0.912 - 0.494)
At least once a week	-0.163	0.180	0.149
	(-0.623 - 0.298)	(-0.140 - 0.500)	(-0.373 - 0.671)
Currently breastfeeding	0.327***	-0.010	-0.512**
	(0.082 - 0.572)	(-0.361 - 0.164)	(-1.020 - -0.005)
Marital status			
Never in union (reference)			
Married or Cohabiting	-0.766*	0.809*	0.248
	(-1.567 - 0.0347)	(0.132 - 1.486)	(-1.131 - 1.626)
Formerly in union	-0.357	0.0680	-0.549
	(-1.126 - 0.413)	(-0.583 - 0.718)	(-1.956 - 0.859)
Decision on large household purchases			
Respondent alone (reference)			
Both Respondent and partner	0.186	0.155	0.885*

	(-0.292 - 0.664)	(-0.291 - 0.601)	(-0.154 - 1.923)
Partner alone	0.436*	0.098	0.423
	(-0.059 - 0.931)	(-0.325 - 0.522)	(-0.370 - 1.215)
Someone else/Other	-0.787	-3.160***	-12.640***
	(-2.567 - 0.993)	(-5.513 - -0.808)	(-14.160 - -11.130)
Decision on respondent's health			
Respondent alone (reference)			
Both Respondent and partner	-0.180	-0.332	-0.743*
	(-0.599 - 0.239)	(-0.731 - 0.067)	(-1.594 - 0.109)
Partner alone	-0.176	-0.525**	-0.602*
	(-0.552 - 0.201)	(-0.933 - -0.116)	(-1.282 - 0.078)
Someone else/Other	1.672**	0.687	-14.200***
	(0.073 - 3.272)	(-1.990 - 3.363)	(-15.970 - -12.430)
Observations	9,506	9,506	9,506

Confidence Intervals (CI) in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 4: Multivariable analysis of the association between sociodemographic correlates and malnutrition, Ghana

Variables	Underweight BMI<18.50	Overweight BMI=25-29.99	Obesity BMI>= 30
Women's Education (in years)	-0.022	0.074***	0.028
	(-0.080 - 0.036)	(0.037 - 0.110)	(-0.014 - 0.070)
Women's Age (in years)	0.054**	0.0405**	0.083***
	(0.005 - 0.103)	(0.008 - 0.073)	(0.048 - 0.118)
Household wealth index			
Poorest (reference)			
Poorer	-0.398	0.367	1.390***
	(-0.972 - 0.177)	(-0.129 - 0.864)	(0.582 - 2.197)
Middle	-1.050***	0.893*	2.804***
	(-1.768 - -0.331)	(0.340 - 1.447)	(1.947 - 3.662)
Rich	-0.529	1.436*	3.591***
	(-1.426 - 0.369)	(0.878 - 1.995)	(2.615 - 4.568)
Richest	-1.788***	1.271*	4.121***
	(-3.052 - -0.523)	(0.555 - 1.988)	(3.125 - 5.117)
Woman currently working (yes)	-0.125	0.121	0.0769
	(-0.713 - 0.463)	(-0.238 - 0.481)	(-0.424 - 0.577)
Place of residence (urban)	0.463*	0.113	-0.073
	(-0.0488 - 0.975)	(-0.250 - 0.477)	(-0.582 - 0.435)
Sex of household head (female)	0.409	0.0971	0.293
	(-0.276 - 1.093)	(-0.309 - 0.503)	(-0.173 - 0.759)
Parity	-0.205**	0.0719	0.0324
	(-0.372 - -0.038)	(-0.055 - 0.199)	(-0.118 - 0.183)
Household size	0.021	-0.047	0.035

	(-0.045 - 0.086)	(-0.121 - 0.027)	(-0.077 - 0.147)
Frequency of watching TV			
Not at all (reference)			
Less than once a week	-0.043	0.231	0.673*
	(-0.604 - 0.518)	(-0.240 - 0.703)	(0.0003 - 1.345)
At least once a week	-0.233	0.248	0.756**
	(-0.754 - 0.287)	(-0.184 - 0.679)	(0.146 - 1.365)
Currently breastfeeding (yes)	0.136	-0.177	-0.471**
	(-0.364 - 0.637)	(-0.525 - 0.171)	(-0.832 - -0.110)
Marital status			
Never in union (reference)			
Married or Cohabiting	-0.536	-0.259	0.295
	(-1.843 - 0.772)	(-0.904 - 0.386)	(-0.860 - 1.451)
Formerly in union	0.271	0.420	1.435*
	(-0.837 - 1.378)	(-0.286 - 1.126)	(0.400 - 2.470)
Decision on large household purchases			
Respondent alone (reference)			
Both Respondent and partner	0.464	-0.0143	-0.0496
	(-0.555 - 1.483)	(-0.523 - 0.495)	(-0.657 - 0.557)
Partner alone	0.664	-0.0223	-0.265
	(-0.217 - 1.546)	(-0.556 - 0.512)	(-0.917 - 0.386)
Someone else/Other	-1.212	-0.0290	0.752
	(-3.637 - 1.213)	(-1.485 - 1.426)	(-1.161 - 2.665)
Decision on respondent's health			
Respondent alone (reference)			
Both Respondent and partner	0.0525	0.785*	0.787*
	(-0.868 - 0.973)	(0.280 - 1.290)	(0.166 - 1.408)
Partner alone	0.119	0.526*	0.915*
	(-0.643 - 0.881)	(-0.0457 - 1.098)	(0.156 - 1.675)
Someone else/Other	-0.714	-1.544	-13.43***
	(-2.832 - 1.403)	(-3.520 - 0.433)	(-15.04 - -11.81)
Observations	3,012	3,012	3,012

Confident Intervals (CI) in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 5: Multivariable analysis of the association between sociodemographic correlates and malnutrition, Kenya

Variables	Underweight (BMI<18.50)	Overweight (BMI=25.29.99)	Obesity (BMI>=30)
Women's Education (in years)	-0.113***	0.013	0.013
	(-0.148 - -0.078)	(-0.016 - 0.042)	(-0.030 - 0.056)

Women's Age (in years)	0.026**	0.066***	0.120***
	(0.001 - 0.052)	(0.046 - 0.089)	(0.087 - 0.153)
Household wealth index			
Poorest (reference)			
Poorer	-0.488***	0.279*	0.633*
	(-0.805 - -0.172)	(-0.025 - 0.582)	(0.080 - 1.187)
Middle	-0.500***	0.609***	0.790*
	(-0.869 - -0.130)	(0.261 - 0.957)	(0.268 - 1.311)
Rich	-0.940***	0.927*	1.690***
	(-1.376 - -0.504)	(0.578 - 1.276)	(1.164 - 2.216)
Richest	-1.307***	1.427***	2.616***
	(-1.946 - -0.668)	(1.042 - 1.813)	(2.049 - 3.184)
Woman currently working (yes)	-0.357***	0.0162	0.210
	(-0.590 - -0.123)	(-0.221 - 0.253)	(-0.110 - 0.529)
Place of residents (urban)	0.0337	0.107	0.497***
	(-0.272 - 0.339)	(-0.115 - 0.330)	(0.177 - 0.817)
Sex of household head (female)	0.230	0.0205	-0.0346
	(-0.0570 - 0.518)	(-0.177 - 0.218)	(-0.336 - 0.267)
Parity	-0.164***	-0.118***	-0.084
	(-0.243 - -0.085)	(-0.190 - -0.046)	(-0.199 - 0.030)
Household size	-0.035	0.013	0.034
	(-0.089 - 0.019)	(-0.034 - 0.061)	(-0.044 - 0.111)
Frequency of watching TV			
Not at all			
Less than once a week	-0.539***	0.076	-0.131
	(-0.905 - -0.174)	(-0.295 - 0.447)	(-0.700 - 0.439)
At least once a week	-0.066	0.043	0.035
	(-0.355 - 0.223)	(-0.194 - 0.281)	(-0.357 - 0.426)
Currently breastfeeding (yes)	0.102	-0.156*	-0.204
	(-0.112 - 0.316)	(-0.338 - 0.026)	(-0.510 - 0.102)
Marital status			
Never in union (reference)			
Married or Cohabiting	0.299	0.870*	0.898*
	(-0.197 - 0.794)	(0.422 - 1.317)	(0.212 - 1.584)
Formerly in union	0.209	0.488**	0.312
	(-0.339 - 0.756)	(0.047 - 0.929)	(-0.392 - 1.017)
Decision on household large purchases			
Respondent alone (reference)			
Both Respondent and partner	-0.217	-0.303**	0.0495
	(-0.546 - 0.113)	(-0.543 - -0.063)	(-0.259 - 0.358)
Partner alone	-0.298*	-0.0677	-0.128
	(-0.641 - 0.045)	(-0.350 - 0.215)	(-0.528 - 0.273)
Someone else/Other	-2.309***	-0.970	-13.66***
	(-4.053 - -0.565)	(-3.170 - 1.231)	(-14.580 - -12.730)
Decision on respondent's health			
Respondent alone (reference)			

Both Respondent and partner	-0.0559	0.0704	-0.131
	(-0.427 - 0.315)	(-0.194 - 0.335)	(-0.524 - 0.262)
Partner alone	-0.220	-0.016	-0.183
	(-0.601 - 0.161)	(-0.301 - 0.268)	(-0.633 - 0.266)
Someone else/Other	-2.446***	0.092	-12.920***
	(-4.226 - -0.666)	(-2.677 - 2.862)	(-14.610 - -11.230)
Observations	9,993	9,993	9,993

Confidence Intervals (CI) in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6: Multivariable analysis of the association between sociodemographic correlates and malnutrition, Mozambique

Variables	Underweight (BMI<18.50)	Overweight (BMI=25-29.99)	Obesity (BMI>=30)
Women's Education (yes)	0.011	0.044***	0.098***
	(-0.041 - 0.063)	(0.0127 - 0.076)	(0.041 - 0.156)
Women's Age (in years)	0.018	0.032***	0.075***
	(-0.013 - 0.049)	(0.012 - 0.052)	(0.042 - 0.109)
Household Wealth index			
Poorest (reference)			
Poorer	-0.146	0.618*	1.061
	(-0.479 - 0.187)	(0.222 - 1.015)	(-0.529 - 2.650)
Middle	-0.741***	0.856*	2.424***
	(-1.118 - -0.365)	(0.430 - 1.282)	(1.023 - 3.825)
Rich	-0.618***	1.235*	2.905***
	(-1.081 - -0.154)	(0.818 - 1.652)	(1.576 - 4.234)
Richest	-0.800***	1.977***	4.832***
	(-1.408 - -0.192)	(1.517 - 2.437)	(3.496 - 6.168)
Woman currently working (yes)	0.195	-0.0795	0.014
	(-0.087 - 0.477)	(-0.271 - 0.112)	(-0.371 - 0.400)
Place of residence (urban)	0.0766	-0.0722	-0.0180
	(-0.306 - 0.459)	(-0.350 - 0.205)	(-0.504 - 0.468)
Sex of household head (female)	-0.342**	-0.056	-0.142
	(-0.649 - -0.036)	(-0.264 - 0.153)	(-0.570 - 0.286)
Parity	-0.124**	0.0379	0.160**
	(-0.224 - -0.023)	(-0.024 - 0.100)	(0.037 - 0.282)
Household size	0.0161	-0.010	-0.037
	(-0.037 - 0.070)	(-0.042 - 0.022)	(-0.108 - 0.035)
Frequency of watching TV			
Not at all (reference)			
Less than once a week	-0.0113	0.157	0.630***
	(-0.328 - 0.306)	(-0.091 - 0.404)	(0.214 - 1.047)
At least once a week	-0.214	-0.0124	0.044
	(-0.518 - 0.0895)	(-0.213 - 0.188)	(-0.329 - 0.418)
Currently breastfeeding	0.215	-0.298***	-0.516**
	(-0.049 - 0.478)	(-0.493 - -0.102)	(-0.938 - -0.0944)

Marital status			
Never in union (reference)			
Married or Cohabiting	0.253	0.196	0.708*
	(-0.419 - 0.925)	(-0.223 - 0.615)	(-0.0469 - 1.462)
Formerly in union	0.351	-0.029	0.773**
	(-0.288 - 0.989)	(-0.462 - 0.404)	(0.0197 - 1.527)
Decision on large household purchases			
Respondent alone (reference)			
Both Respondent and partner	-0.096	-0.0634	-0.0414
	(-0.472 - 0.281)	(-0.329 - 0.202)	(-0.647 - 0.564)
Partner alone	-0.049	0.037	-0.366
	(-0.420 - 0.323)	(-0.256 - 0.329)	(-1.022 - 0.289)
Someone else/Other	0.036	0.746	-0.983
	(-1.044 - 1.115)	(-0.600 - 2.091)	(-3.268 - 1.303)
Decision on respondent's health			
Respondent alone (reference)			
Both Respondent and partner	-0.184	-0.134	-0.143
	(-0.633 - 0.265)	(-0.425 - 0.158)	(-0.777 - 0.491)
Partner alone	-0.317	-0.148	0.227
	(-0.786 - 0.151)	(-0.440 - 0.144)	(-0.360 - 0.814)
Someone else/Other	-0.480	-0.646	-1.232
	(-1.477 - 0.516)	(-1.649 - 0.357)	(-3.319 - 0.855)
Observations	11,017	11,017	11,017

Confidence Intervals (CI) in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 7: Multivariable analysis of the association between sociodemographic correlates and malnutrition, Nigeria

Variable	Underweight (BMI<18.50)	Overweight (BMI=25-29.99)	Obesity (BMI>=30)
Women's Education (in years)	-0.042***	0.034***	0.048***
	(-0.067 - -0.018)	(0.019 - 0.049)	(0.028 - 0.068)
Women's Age (in years)	-0.019**	0.040***	0.072***
	(-0.035 - -0.0021)	(0.030 - 0.051)	(0.056 - 0.088)
Household wealth index			
Poorest (reference)			
Poorer	-0.200**	0.289***	0.208
	(-0.366 - -0.034)	(0.090 - 0.488)	(-0.280 - 0.697)
Middle	-0.291**	0.691***	0.788*
	(-0.517 - -0.0650)	(0.479 - 0.903)	(0.298 - 1.278)
Rich	-0.208	0.998*	1.196*
	(-0.477 - 0.0614)	(0.764 - 1.232)	(0.694 - 1.698)
Richest	-0.530***	1.351***	1.862***
	(-0.921 - -0.139)	(1.074 - 1.628)	(1.353 - 2.372)

Woman currently working (yes)	-0.0518	0.0231	-0.292***
	(-0.198 - 0.0944)	(-0.102 - 0.148)	(-0.497 - -0.0878)
Place of residence (urban)	0.166	0.0775	0.178*
	(-0.0500 - 0.381)	(-0.0643 - 0.219)	(-0.0244 - 0.379)
Sex of household head (female)	-0.0836	0.0127	-0.084
	(-0.336 - 0.169)	(-0.149 - 0.174)	(-0.300 - 0.133)
Parity	-0.011	0.039**	0.0230
	(-0.0538 - 0.0313)	(0.009 - 0.0698)	(-0.021 - 0.067)
Household size	0.007	-0.009	0.023*
	(-0.015 - 0.029)	(-0.025 - 0.00654)	(-0.002 - 0.047)
Frequency of watching TV			
Not at all (reference)			
Less than once a week	-0.146	0.0771	0.0585
	(-0.336 - 0.045)	(-0.056 - 0.210)	(-0.162 - 0.278)
At least once a week	-0.252***	0.155**	0.205*
	(-0.438 - -0.066)	(0.024 - 0.285)	(-0.009 - 0.420)
Currently breastfeeding	0.178***	-0.176***	-0.363***
	(0.043 - 0.314)	(-0.278 - -0.073)	(-0.524 - -0.202)
Marital status			
Never in union			
Married or Cohabiting	-0.177	0.633*	0.557*
	(-0.652 - 0.299)	(0.188 - 1.078)	(-0.090 - 1.204)
Formerly in union	0.0721	0.921*	1.071*
	(-0.400 - 0.545)	(0.426 - 1.416)	(0.417 - 1.724)
Decision on large household purchases			
Respondent alone			
Both Respondent and partner	-0.206	0.0218	0.341*
	(-0.641 - 0.230)	(-0.209 - 0.252)	(-0.002 - 0.684)
Partner alone	-0.181	-0.015	-0.177
	(-0.579 - 0.218)	(-0.238 - 0.209)	(-0.538 - 0.184)
Someone else/Other	1.314*	-0.651	-0.225
	(-0.239 - 2.866)	(-1.912 - 0.609)	(-1.731 - 1.281)
Decision on respondent's health			
Respondent alone (reference)			
Both Respondent and partner	-0.0847	-0.0141	-0.192
	(-0.525 - 0.356)	(-0.251 - 0.223)	(-0.547 - 0.163)
Partner alone	0.069	0.025	-0.088
	(-0.334 - 0.474)	(-0.206 - 0.256)	(-0.460 - 0.283)
Someone else/Other	-2.381***	-1.369**	-2.604**
	(-1.417 - -0.423)	(-4.688 - -3.669)	(-7.160 - -5.311)
Observations	31,170	31,170	31,170

Confidence Intervals (CI) in parentheses

*** p<0.01, ** p<0.05, * p<0.1

The figures 1 and 2 are pictorial presentations of the probability of women falling into underweight, overweight and obese categories if there were changes in their age and years of education.

Figure 1: Graphical Illustration of the results of the probability of falling into the DBM categories when years of education increase

Figure 2: Graphical Illustration of results of the probability of falling into the DBM categories when age increases

Discussion

This study investigated the correlates of DBM among women in five sub-Saharan African (SSA) countries. The key indicators of DBM used in the analysis were, underweight, overweight and obesity. The results showed expectedly that there are some variations across countries on how the correlates included in this study are associated with DBM. Our analysis reveals that in Ghana, Mozambique and Nigeria, a higher number of years of formal education is associated with the likelihood of overweight and obesity relative to normal weight women. Thus, a higher number of years of education is a risk factor for women with unhealthy weight. This could be due to lifestyles changes as one achieve more years of education, which may include sedentary lifestyles and poor dietary patterns (32). Further, it could be that people who are already overweight or obese have higher propensity of adding more weight relative to those who have normal weight. In contrast, there was an inverse relationship between the number of years of formal education and underweight in Kenya and Nigeria. These findings are in line with previous studies. In Ghana, higher

education was associated with overweight and obesity among women (33). Additionally, high education was associated positively with overweight among women in Indonesia (34). Nevertheless, in the same study, high education was associated with reduced risk of being underweight by 10–30% (34). This is contrary to our findings in Kenya and Nigeria.

Furthermore, age was associated positively with all the DBM indicators across the five countries. Thus, older women are more likely to be overweight and obese and less likely to be underweight. This suggests that older age is a protective factor for underweight, while a risk factor for overweight and obesity. This positive correlation between age, and overweight and obesity, may have a consequential effect on non-communicable diseases (NCDs) among older people, as an unhealthy weight is a major risk factor for NCDs (35-38). An exception to these findings could be made of Nigeria where older age was associated negatively with underweight women. This implies that in this setting, the older women become the more likelihood that they will suffer from underweight. The consequential effect of this may be poor health outcomes, as being underweight exposes women to higher risks of morbidity and mortality during pregnancy and child birth (39-41). The relationship between age and DBM has been documented in previous studies. For example, Doku and Neupane observed a significant positive association between age and the key indicators of DBM in Ghana (33). A study in Bangladesh observed a significant positive relationship between older age and DBM (42). These findings together with the findings from our study confirmed the contribution of age to the DBM epidemic.

Our analysis showed that household wealth index had mixed effects on DBM. In general, the three rich quintiles: middle, richer and richest were associated significantly and positively with overweight and obesity among women across all the countries included in the analysis. This may be due to obesogenic effects of increased household wealth as dietary pattern changes (43), and the fact that there is a documented positive correlation between household wealth and unhealthy body weight (44, 45). In Bangladesh and Nepal, higher household wealth was associated with an increased likelihood of being overweight and obese (44). Also, being rich was associated with overweight and obesity among Ghanaian women (33). Interestingly, higher household wealth had an inverse effect on underweight. This inverse relationship may be due to the fact that most underweight women are likely to be in the poorer wealth quintiles (46) and therefore, may be unaffected by the higher household wealth quintiles. The inverse relationship has been observed previously (47). Relatedly, compared to the richest, women from the poorest households were significantly most likely to be underweight and least likely to be overweight over normal weight in Bangladesh (17). Suggesting that being in the poorest household is protective against overweight but not underweight (46).

The health benefits of breastfeeding were illuminated in this study. Breastfeeding was found to associate with less likelihood of underweight, overweight and obesity in the five countries analysed. This suggests that mothers who have unhealthy weight should be encourage to practice breastfeeding as the benefits are not only to their offspring but also for their own health and wellbeing. These findings confirm the widely recognized benefits of breastfeeding for improved health and developmental outcomes in mothers and their infants (48-51). The implication of this

may be that interventions to promote breastfeeding may have positive impact on the DBM epidemic at the national level. The benefits of breastfeeding to women health have previously been documented. For example, breastfeeding has been suggested as an efficient means of promoting postpartum weight loss due to its high energy cost (52). Further evidence suggest that at 12 weeks postpartum, exclusively breastfeeding (EBF) mothers had lost more total body weight than mixed feeding mothers. However, mixed feeding mothers lost slightly more percent body fat than exclusively breastfeeding mothers (52).The authors concluded that EBF promotes greater weight loss than mixed feeding among mothers even in the early postpartum period. Several other studies have shown that EBF influences postpartum weight loss (51-54). The preceding discussion points to the need for health policy makers to design programmes to encourage mothers to breastfeed, especially, practice exclusive breastfeeding as a means of DBM prevention.

An important strength of our study is the use of large nationally representative samples, thereby providing more robust estimates of observed associations as well as enhancing the generalizability of the findings. The use of multi-country data help unmask differences and commonalities in the effects of the correlates on DBM across countries, which would not have been possible with single country data. Additionally, the height and weight data which were used to compute the BMI were objectively measured, reducing possible misclassification. A limitation worth mentioning is the cross-sectional nature of the data, which does not lends itself to the establishments of causal relationship between the predictor and outcome variables. The conclusions in the paper are therefore interpreted as mere associations between the predictor variables and the outcome variable. Another limitation is that due to data limitation, we were not able to examine DBM at the

individual and within households. The analysis and interpretation in this paper are therefore limited to DBM at population or national level, whereby underweight, overweight and obesity co-exist in the same country.

Conclusions

The study investigated the correlates of the DBM in five SSA countries. The analysis revealed that the effects of the correlates on DBM are largely similar across countries, except in few cases where there were disparities in the effects. The results indicate that higher number of years of education increases the likelihood of overweight and obesity among women in Ghana, Mozambique and Nigeria. Conversely, number of years of education is associated negatively with underweight in Kenya and Nigeria. Living in better-off households increases significantly the likelihood of overweight and obesity among women across all countries, while associated with the likelihood of underweight. Interventions to address DBM should take into account socioeconomic status. This may include providing special programmes for women who have unhealthy weight in wealthy households. A unit change in age is also associated significantly and positively with underweight, overweight and obesity in all the countries included in the analysis. Breastfeeding is associated with least likelihood of underweight, overweight and obesity in breastfeeding mothers. This implies that interventions to prevent DBM should incorporate breastfeeding to enhance their effectiveness.

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Competing Interest

The authors have no competing interests to declare.

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Data Sharing Statement

This study was a re-analysis of existing data that are publicly available from The DHS Program at http://dhsprogram.com/publications/publication-fr221-dhs-final-reports.cfm. Data are accessible free of charge upon a registration with the Demographic and Health Survey program (The DHS Program). The registration is done on the DHS website indicated above.

Authors' Contribution

DAA conceived and designed the study. DAA and ZTD conducted the data analysis, interpreted the results and drafted the manuscript. CK contributed to study design, data analysis, interpretation, and critical revision of the manuscript. All authors take responsibility of any issues that might arise from the publication of this manuscript.

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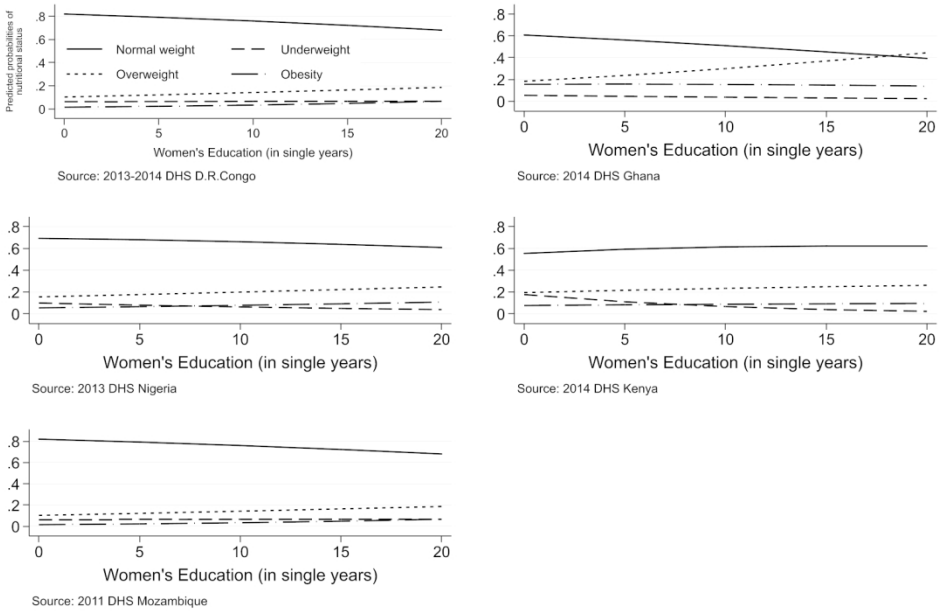

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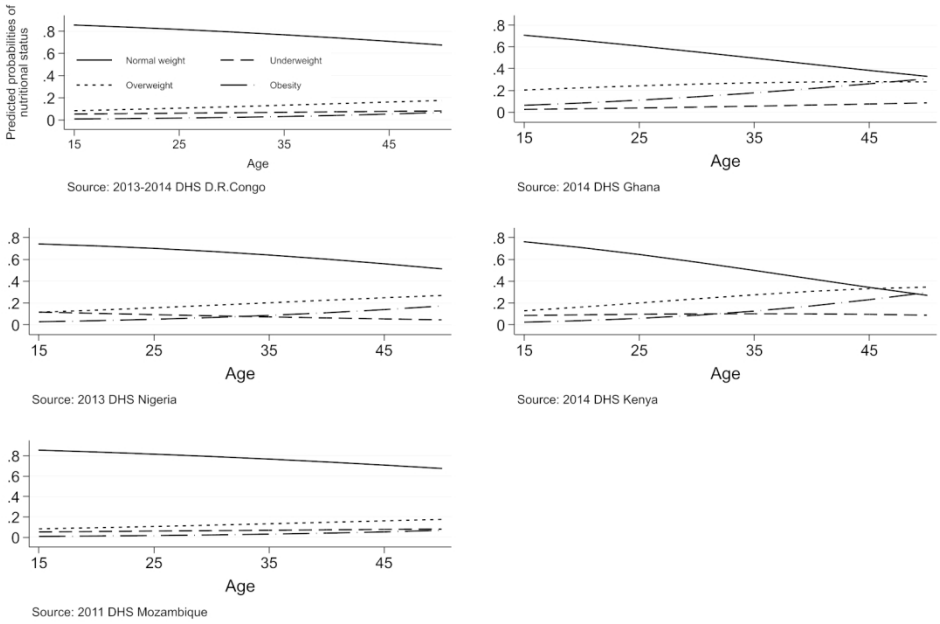

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STROBE 2007 (v4) Statement—Checklist of items that should be included in reports of *cross-sectional studies*

Section/Topic	Item #	Recommendation	Reported on page #
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract	1
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found	2
Introduction			
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported	4-6-
Objectives	3	State specific objectives, including any prespecified hypotheses	7
Methods			
Study design	4	Present key elements of study design early in the paper	7-8
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection	7-9
Participants	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants	8
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable	8-9
Data sources/ measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group	8-9
Bias	9	Describe any efforts to address potential sources of bias	
Study size	10	Explain how the study size was arrived at	
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why	9-10
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding	9-10
		(*b*) Describe any methods used to examine subgroups and interactions	9-10
		(*c*) Explain how missing data were addressed	9-10
		(*d*) If applicable, describe analytical methods taking account of sampling strategy	
		(*e*) Describe any sensitivity analyses	NA
Results			

Participants	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed	8
		(b) Give reasons for non-participation at each stage	8
		(c) Consider use of a flow diagram	NA
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders	11-12
		(b) Indicate number of participants with missing data for each variable of interest	NA
Outcome data	15*	Report numbers of outcome events or summary measures	NA
Main results	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included	9-10
		(*b*) Report category boundaries when continuous variables were categorized	10
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period	NA
Other analyses	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses	NA
Discussion			
Key results	18	Summarise key results with reference to study objectives	21
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias	24
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence	21-24
Generalisability	21	Discuss the generalisability (external validity) of the study results	25
Other information			
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based	NA

*Give information separately for cases and controls in case-control studies and, if applicable, for exposed and unexposed groups in cohort and cross-sectional studies.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.