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Prevalence of low-birthweight and its association with maternal body weight status in selected countries in Africa

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Abstract

Background: Despite the programmatic efforts to reduce the burden of infant mortality within the framework of Millennium development goals, low-birthweight (LBW) remains a major public health concern across Africa.

Objective: The present study aimed to: 1) estimate the prevalence of LBW, and to 2) investigate the association between maternal body weight measured in terms of BMI and birthweight in selected countries in Africa.

Setting and Participants: Cross-sectional data on 11,418 mother-child pair were collected from most recent Demographic and Health Surveys in Burkina Faso, Ghana, Malawi, Senegal, and Uganda. Mothers' age ranged between 15 and 49 years.

Outcome measures: Low-birthweight and maternal BMI were measured according the cut-offs recommended by WHO. Bivariate and multivariate regression methods were used to examine the association between maternal BMI and birthweight.

Results: Prevalence of LBW in Burkina Faso, Ghana, Malawi, Senegal and Uganda was respectively 13.4%, 10.2%, 12.1%, 15.7%, and 10%. Compared to women who are normal weight, underweight mothers had a higher likelihood of giving birth to LBW babies in all countries except for in Ghana: Burkina Faso [OR=1.304 (0.974-1.745)], Ghana [OR=1.030 (0.453-2.342)], Malawi [OR=1.449(0.936-2.242)], Senegal [OR=1.961 (1,259-3.055)] and Uganda [OR=1.363 (0.587-3.169)]. In Malawi, odds of giving birth to LBW babies were 22% lower [95%CI=0.533-1.141] among overweight/obese women compared to those who were normal weight.

Conclusion: Underweight mothers share a greater risk of having low birthweight babies compared to their normal weight counterparts. Programs targeting to address infant mortality should focus on promoting nutritional status among women of childbearing age. Longitudinal studies are required to better elucidate the causal nature of the relationship between maternal underweight and LBW.

Strengths and limitations of this study

- Based on nationally representative samples, this is first study to explore the association between maternal BMI and LBW across five different countries in Africa. The relatively large sample size provides a robust precision of the estimation

- This study also provides an update on maternal BMI and LBW scenario, and reports the comparison of prevalence rates of these two important health indicators in these countries.

- Owing to data constraints, some relevant sociocultural factors that could have affected the association were not included in the analysis.

- The cross-sectional nature of the data prevents making any causal relationships.

Introduction

Last few decades have experienced an appreciable reduction in the burden of infant mortality rates (IMR) thanks to the programmatic efforts within the framework of Millennium Development Goals (MDGs). Compared to 1990, the rate of under-five mortality has declined by about half in 2013 (90% in 1990 vs 46% in 2013 per 1,000 live births) [1]. Despite this progress in terms of total child mortality, the prevalence of neonatal mortality is still on the rise (38% in 2000 vs 45% in 2015), which poses significant barriers to the fulfilment of the MDGs [2]. Globally, preterm birth (28%), severe infections (26%), and asphyxia (23%) constitute the most important causes of neonatal death [2,3]. However low–birthweight (weighing <2500g at birth) is also considered a crucial underlying determinant and contributor to neonatal and infant mortality [3,4]. LBW accounts nearly half of all perinatal and one-third of all infant deaths [6]. Compared to normal birth weight (NBW) babies, LBW babies are 40 times more likely to die within first thirty days of life [6]. In African countries, low birth weight is claimed to be the strongest predictor of infant morbidity and mortality [7]. Given its critical importance on child survival, LBW was adopted as one of a number of health indicators as part of the global strategy for health in the 34th assembly of World Health Organization (WHO) in 2000.

Regional statistics suggest that the global burden of neonatal mortality is heavily skewed towards developing countries which account for nearly all LBW cases [6]. According to WHO estimates, out of more than 20 million LBW babies (representing 15.5% of all live births) nearly 95.6% takes place in the low-and-middle income countries (LMICs) [6]. Evidence from South Asian countries, highest LBW prevalent global region, shows that majority of the neonatal death occurred among those who weighed less than 2500g at birth (54% in Pakistan and 79.5% in India) [4,5]. Apart from the higher likelihood of neonatal mortality, LBW babies in later periods of life face greater risks of poor cognitive development, impaired immunity, developing chronic medical conditions and neurodegenerative diseases [8-10]. According to UNICEF, LBW babies are 50% more likely to face serious development problems including mental retardation, learning disabilities, academic underperformance and lower IQ. Compared to developed countries, the chance of survival and healthy living among LBW babies in developing countries are further limited by poor healthcare infrastructure and substandard environmental and living conditions [11]. Besides its direct consequences on physical and mental health, LBW has important socioeconomic bearings e.g. low workplace productivity, increased spending on healthcare with adverse impacts on national development imperatives in the aggregate [10-12]. Besides being a significant determinant of the chances for survival and long-term health status of infants, LBW also serves as an indicator of health, nutritional and socioeconomic status of the mother [13-14].

There exists a number of studies that have attempted to identify the causes of LBW and have shown that the factors fall into a diversity of socioeconomic, biological, psychological, and nutrition-related factors [10-16]. The themes that commonly emerge from the previous studies include maternal height and weight, level of education, socioeconomic status, adherence to adequate antenatal care services, order and number pregnancies [15-18]. However, only a handful of the studies are based on country representative population, and results remain mixed. For the countries included in the present study, there is not yet any comprehensive study investigating the cause or factors of association with LBW. In this study, however, maternal BMI was the determinant of primary interest among all maternal characteristics. The justification of selecting BMI as the variable (maternal level) of main interest is the rising incidence of overweight and obesity in parallel with the existing burden of undernutrition in Sub-Saharan Africa. Results from a systematic review on Global Burden of Disease Study reveals that the proportion of overweight among adult women in developing countries has increased from 29.8% in 1980 to 38.0% in 2013 [19]. From a maternal and child health perspective, this epidemiological shift is a growing concern for African nations for the demonstrated impact of unhealthy BMI of mothers on poor birth outcomes [2-7]. Research evidence on the association between maternal BMI and LBW can be useful in informing policy making and health promotion programs. No wonder, most of the countries lack a well-developed birth registry system which poses challenges for conducting researches on nationally representative sample. To overcome this barrier, datasets from DHS surveys were used.

Methodology

Study setting, sampling and data collection

The study is based on cross-sectional data collected from recent Demographic and Health Surveys (DHS) in five Sub-Saharan countries: Burkina Faso, Ghana, Malawi, Senegal, and Uganda. Details about the year, implementing body and response rates are listed in **Table 1**. DHS surveys operate in developing countries with an aim to conduct quality studies on basic demographic and health indicators on under-five children, men (aged 18 to 59) and women (aged 18 to 49). Among many, the dominant themes of the surveys include childhood mortality, family planning and fertility, maternal and child health, nutrition, health-related knowledge and behaviour [20]. The main objectives of the program are to provide quality data on public health issues and increased dissemination and utilization of the data to promote evidence-based health policy-making [20]. DHS programs work in collaboration with local and international development partners to implement the survey programs with financial support from the United States Agency for International Development (USAID) and technical assistance by ICF International.

The surveys collect information by using standardized questionnaires on various themes on eligible samples and other members of the households. For sampling, DHS employs a two-stage clustering design of the population which involves labelling the smallest administrative units as enumeration areas (EAs) or clusters. Selection of EAs is based on their size proportional to that of the units. In the second step, households are selected systematically from each EA to ensure effective sampling. DHS provides no exact information on the spatial dimension of EAs. However, it consists about hundred to 30 thousand households varying from country to country.

Table 1: Description of the surveys for the countries and included in the study.

Country	Round	Implementing body	Year	Sample (Response rate)
Burkina Faso	DHS-VI	Institut National de la Statistique et de la Démographie	May 2010 -January, 2011	17,087 (98.4%)
Ghana	DHS-VII	Ghana Statistical Service (GSS), the Ghana Health Service (GHS)	January-March, 2014.	9,396 (97.3%)
Malawi	DHS-VI	National Statistical Office of Malawi (NSO)	June- November, 2010	23,020 (96.9)
Senegal	DHS-VI	Agence Nationale de la Statistique et de la Démographie (ANSD)	2010-11,	15,688 (92.7)
Uganda	DHS-VI	Uganda Bureau of Statistics (UBOS)	June- December 2011.	8,674 (93.8)

Subjects

Mother of at least one child ageing between 15 and 49 years and living in non-institutional residences in: Burkina Faso, Ghana, Malawi, Senegal, and Uganda.

Variables

Dependent variable: The dependent variable in this study was birth weight for the most recent child. As per WHO classification, birth weight was categorized as low birth weight (LBW) < 2500gm and normal birth weight (NBW) ≥2500gm.

Explanatory variable: As per WHO recommendation, BMI was categorized in the following way: Underweight (<18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight & obese (≥25kg/m^2).

Covariates: Demographic and socioeconomic variables that could influence the associations between maternal BMI and LBW were included in the multivariable analyses. Based on the insights from literature review, and availability on the datasets, the following variables were included as potential confounders in this study: Maternal age; Area of residence: urban/ rural; Educational attainment: Nil/primary/secondary& higher;

Household wealth status*: poorest, poorer, middle, richer and richest; parity: <3/≥3; ANC**: <4/≥4; Pregnancy aspiration (most recent pregnancy): Yes/no.

*As DHS do not collect data on individual income, this study used household wealth index as a proxy for economic status. It is calculated based on factors scores generated by principal component analysis on of ownership of household assets e.g. source of drinking water, type of toilet facility, type of cooking fuel, ownership of TV, refrigerator. Based on individual scores households fall into five categories on the wealth index: poorest, poorer, middle, richer and richest [22].

**The World Health Organization (WHO) recommends at least four ANC visits during the course of normal pregnancies.

Data analysis

Data were analysed using SPSS® version 22. Respondents for whom there was no information on height or weight were excluded from the analysis. Basic characteristics of the sample, including the prevalence rates were presented as frequencies and percentages. Since the dependent variable was dichotomous in nature, a binary logistic regression technique was performed to examine the association between maternal BMI and LBW. Separate bivariate and multivariate models were run for each country included in the analysis. Each of the background variable that showed a significance level of 0·25 in the bivariate analysis (as proposed by Hosmer and Lemeshaw) were retained for multivariable analysis [21]. Results of multivariate analysis were presented as Odds Ratios and 95 % confidence intervals. Before regression analysis, variance inflation factor (VIF) was used to check for collinearity and to ensure that the assumptions of multi-collinearity were not violated. All statistical tests were two-tailed and a $p < 0.05$ was considered statistically significant.

Result

Sample characteristics

The basic sociodemographic characteristics of the sample population for individual countries are presented in **Table 2 and 3**. Results indicate that average age was lowest at 28.1 years for Malawi and highest at 30.34 years for Ghana (SD 6.63). Women from all countries were predominantly rural origin and the percentage ranged from 86.8% in Malawi to 57.1% in Ghana. Regarding educational status, Malawi had the highest literacy rate (86.7%) followed by Uganda (83.7%) and Ghana (75.1%). The majority of the women in all countries reported living in poorest to middle wealth status households. Percentage of participants from richest wealth status was highest for Burkina Faso (24.1%) and lowest for Senegal (13.5%). Women in Burkina Faso had the highest parity (62.2%) with the majority of the women in Ghana, Malawi and Uganda had given birth to less than three children. The rate of the antenatal visit for last pregnancy was low in all the countries ranging from over a quarter in Senegal (27.3%) to about three-fifth in (59.9%) in Burkina Faso. Well above half of the women in Ghana (71.4%) and Uganda (54.4%) reported their last pregnancy as unintended.

Prevalence data

Prevalence of underweight among women was highest for Senegal (16.1%) and lowest for Malawi (5.9%) and that of overweight was lowest for Ghana (41.9%) and lowest for Burkina Faso (11.3%). Prevalence of underweight was highest in Senegal (15%) followed by Ghana (10.4%) and Malawi (10.1%) and was lowest in Uganda (5.3%). Mean birth weight in Burkina Faso, Ghana, Malawi, Senegal and Uganda were respectively 2.97 (0.52), 3.25 (0.7), 3 (0.7), 3.35 (0.48). That of LBW was 13.4%, 10.2%, 12.1%, 15.7%, 10 % in the abovementioned order (Table 3).

Table 2: Basic socio-demographic characteristics of the study sample by country.

Variables	Burkina Faso	Ghana	Malawi	Senegal	Uganda
	N=3743	N=1338	N=3113	N=1665	N=1559
Age	29.09 (7.1)	30.34 (6.63)	28.1 (6.86)	28.93 (9.21)	28.78 (7.08)
Region					
Urban	30.9	46.4	13.2	42.9	18.8
Rural	69.1	53.6	86.8	57.1	81.2

Education					
Nil	75.7	24.9	12.3	62.2	16.3
Primary	15.4	18.5	67.9	25.8	58.9
Secondary/Higher	8.8	56.6	19.8	12.1	24.8
Wealth index					
Poorest	13.7	23.2	17.3	23.5	23.9
Poorer	17.1	16.6	19.7	24.6	18.9
Middle	20.8	21.4	22.3	20.2	16.5
Richer	24.4	19.7	21.7	18.2	17.0
Richest	24.1	19.1	19.0	13.5	23.7
Parity					
<3	37.8	52.7	61.0	45.2	53.7
≥3	62.2	47.3	39.0	54.8	46.3
ANC					
<4	59.9	6.7	52.8	27.6	47.7
≥4	40.1	93.3	47.2	72.4	52.3
Last pregnancy intended					
Yes	89.3	28.6	46.0	61.0	45.2
No	10.7	71.4	54.0	39.0	54.8
BMI					
Underweight	11.0	4.5	5.9	16.1	10.2
Overweight/Obese	11.3	41.9	17.6	21.5	19.4
Normal weight	77.7	53.7	76.5	62.4	70.4

Figure 1: Percentage of LBW babies in individual countries stratified by region.

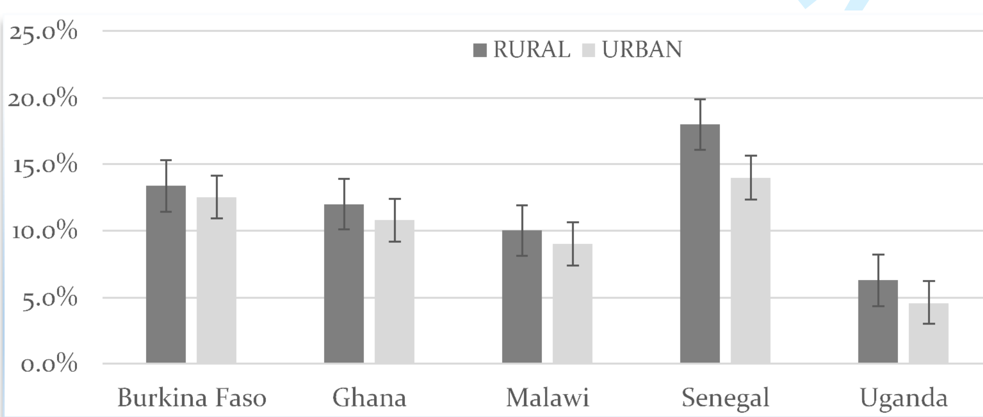

Figure 1 illustrates the percent distribution of LBW babies between urban and rural regions in the individual countries. It shows that prevalence of LBW was higher in rural areas for all countries. Regional difference in LBW prevalence was most noteworthy for Senegal.

Results of chi-square tests are shown in Table 3. It shows that mothers aging more than 35 years, being of rural origin, having to formal education, living in poorer to poorest wealth status were more likely to give birth to LBW babies. The likelihood of having LBW babies were also higher among those with lesser parity, attending less than four ANC visits, and reported last pregnancy as unintended. Underweight mothers had a higher likelihood of having LBW babies compared to overweight/obese mothers.

Table 3: Percentage of LBW babies across maternal socioeconomic and BMI status.

Variables	Burkina Faso	Ghana	Malawi	Senegal	Uganda
	13.4%	**10.2%**	**12.1%**	**15.7%**	**10 %**
Age					
<35	79.6	79.1	78.7	22.9	15.7
35+	20.4	20.9	21.3	77.1	84.3
p	**0.025**	**0.016**	**0.124**	0.030	**0.001**
Region					
Urban	31.1	48.2	14.0	46.2	44.6
Rural	68.9	51.8	86.0	53.8	55.4
p	0.479	0.360	0.356	**0.000**	**0.003**
Education					
Nil	78.1	22.3	15.6	68.3	13.3
Primary	14.4	19.4	69.5	22.1	48.2
Secondary/Higher	7.5	58.3	14.9	9.6	38.6
p	**0.179**	**0.158**	**0.024**	**0.000**	**0.013**
Wealth index					
Richest	13.1	14.4	14.6	14.1	21.7
Richer	16.1	12.9	21.6	20.5	9.6
Middle	23.8	18.0	21.9	22.5	12.0
Poorer	25.3	25.2	22.2	18.5	21.7
Poorest	21.7	29.5	19.7	24.5	34.9
p	**0.168**	0.041	**0.149**	**0.209**	**0.027**
Parity					

<3	46.6	45.3	44.4	43.4	39.8
≥3	53.4	54.7	55.6	56.6	60.2
p	0.001	0.04	0.021	0.253	0.385
ANC					
<4	59.9	9.4	58.7	26.5	45.8
≥4	40.1	90.6	41.3	73.5	54.2
p	**0.136**	**0.123**	**0.015**	**0.113**	**0.000**
Last pregnancy intended					
Yes	10.7	25.9	47.0	61.0	49.4
No	89.3	74.1	53.0	39.0	50.6
p	0.251	0.139	0.173		0.000
BMI					
Underweight	13.5	36.0	14.9	21.7	19.3
Overweight/Obese	9.9	5.0	8.3	9.2	7.2
Normal weight	76.6	59.0	76.8	69.2	73.5
p	**0.018**	**0.04**	**0.000**	**0.019**	**0.116**

N.B. p-value from chi-square test.

Association between maternal body mass index and LBW

Results of the bivariate and multivariable logistic regression are presented in Table 3 and 4. Results explain that in the bivariate analysis underweight among mothers was associated with higher odds of LBW in all the study countries. Among underweight mothers compared to normal weight, the odds of having LBW babies were respectively 29%, 45%, 50% higher in Burkina Faso, Malawi, and Uganda. Underweight mothers in Senegal had the highest odds 90% of having LBW babies. Overweight/obese mothers in Burkina Faso and Ghana had respectively 13% [95%CI=0.629-1.203] and 24% [95%CI=0.522-1.116] lower odds of having LBW babies.

As shown in Table 4 and Table 5, the nature of the association between maternal BMI and LBW remained nearly the same for all the countries after adjusting for other variables in the models. Compared to normal weight mothers, underweight mothers in Burkina Faso, Malawi, Senegal and Uganda had respectively 30%, 45%, 96% and 36% higher odds of having LBW babies. For overweight/obese mothers Ghana and Uganda, the odds of having LBW babies were respectively 7% [95%CI=0.676-1.343] and 22% [95%CI=0.533-1.141] lower.

For sensitivity analysis, we performed the regression analysis with different combinations of explanatory variables (not shown), and calculated crude odds ratio. The results did not show any significant deviation from the final analysis.

Table 4: Association (Crude) between maternal BMI and LBW, in selected countries in Africa.

	Burkina Faso	Ghana	Malawi	Senegal	Uganda
Birth weight					
Normal	-	-	-	-	-
Underweight	1.298 (0.977-1.724)	1.026 (0.460-2.286)	1.454 (0.948-2.230)	1.909 (1.242-2.933)	1.501 (0.652-3.457)
Overweight	0.870 (0.629-1.203)	0.763 (0.522-1.116)	0.972 (0.593-1.154)	1.048 (0.753-1.457)	1.156 (0.602-1.854)

N.B. Reference category is NBW.

Table 5: Association (Adjusted) between maternal BMI and LBW in selected countries in Africa.

	Burkina Faso	Ghana	Malawi	Senegal	Uganda
Birth weight					
Normal	-	-	-	-	-
Underweight	1.304 (0.974-1.745)	1.030 (0.453-2.342)	1.449 (0.936-2.242)	1.961 (1,259-3.055)	1.363 (0.587-3.169)
Overweight	0.933 (0.676-1.343)	0.780 (0.533-1.141)	0.998 (0.638-1.265)	1.088 (0.774-1.530)	1.065 (0.526-1.129)

N.B. Regression model adjusted for all the sociodemographic variables which showed significant association p<0.25 in cross-tabs.

Discussion and policy recommendation

The present study was an attempt to provide an updated scenario on the LBW situation in selected countries in Africa. The rate of LBW for the countries included in this study were found to be similar to regional estimate of 13%, lower than in south Asia 28% and global average for developing countries 16.5% [23,24]. However, the level is still twice as high compared to developed country average 7% [24]. Countries in Sub-Saharan Africa rank second in terms of the prevalence of LBW after South Asia. As seen at the global level, the rate of progress towards MDGs has been uneven across the countries included in this study. Among the five countries we studied, only Burkina Faso experienced some reduction in the prevalence of LBW during the last decade 18% in 2003 vs 13.4% in 2010-11 [25]. For Ghana and Malawi, the situation has worsened considerably since their previous estimates (2% in 2003 Vs 10.2 in 2014) for Ghana, and (5% in 2000 Vs 10 % in 2010) [26-27].

The rise in the burden of LBW in these countries serves as an indication of a poor/inadequate implementation of national health policies to realise the MDG goals targeted at improving child health outcomes (MDG 4 and 5). This deserves special research attention delving into the underlying causes of the rise in LBW prevalence and call for employing more robust policy agenda to reverse the situation. A commonly proposed strategy to prevent maternal and childbirth-related complications is to take early precaution by providing necessary care for pregnant mothers through antenatal care services. Our results show that the rate of ANC attendance was very low for all the countries. National LBW prevention policies should also focus on strategies to improve ANC visits among mothers, particularly in the rural areas. Besides that, ANC visits have found to be effective in encouraging institutional deliveries which itself reduces the risk of birth-related complications and increases the rate of weighing at birth and thus helps in better monitoring of LBW rates. In Uganda, for instance, the majority of births (about 70%) during the five years preceding the survey were not weighed [28]. This is understandable given that fact that only 37 % of total childbirths have taken place in a health facility.

In line with past findings, our results showed that mothers who were underweight were at higher risk of having low birth weight babies compared with normal weight mothers. Previously, a systematic review including 42 studies found that both in developed and developing countries children born to underweight mother were at higher risk of being low birthweight compared with those born to women with normal weight [31]. This finding was supported by a recent meta-analysis in the context of low-and-middle-income countries: low birthweight was significantly associated with maternal underweight, but not maternal overweight/obesity [32]. This finding warrants for strong policy attention to address undernutrition among mothers especially because of its intergenerational effects. Though the situation has seen some progress during last 8-10 years, about 5 to 20% women in Africa still suffer from maternal malnutrition due to chronic hunger with adverse consequences on birthweight and infant and maternal mortality [33]. The rate of underweight has declined for Burkina Faso from 20.9% in 2003 in to 11% in 2010-11, Ghana from 9% in 2003 to 4.5% in 2014, Malawi from 9% in 2000 to 5.9% in 2010, Senegal from 21% in 2005 to 16.1% in 2010-11 [25-27]. For Uganda however no visible progress has been achieved since 2010 (10.4% in 2000-01 to 10.2% in 2011) [28]. As undernutrition itself is a multifactorial problem, the solution will require developing cross-cutting policies and placing the issue on broad national health and development agenda.

Regarding the impact of overweight/obesity on birthweight outcomes on the other hand, current research evidences are still not sufficiently clear and varies across and within countries. Notably, finding of the present study suggest a protective effect of overweight/obesity on LBW among Ghana and Malawian women. This finding is consistent with an Indian study based on National Family Health Survey NFHS 2, 1998-99 [34]. This finding was supported by another conducted in a different Asian setting reporting that the odds of having LBW babies were more than double in underweight women compared to non-obese women [34]. However, these findings conflict with one meta-analysis study which reported that maternal overweight/obesity was associated with lower risk of LBW in developing countries, but the effect did not remain effective after controlling for publication bias [35]. The protective effect of maternal overweight/obesity, however, should not be regarded as a recommendation since it is involved with a range of fetal growth and obstetric complications [29-30]. Overweight/obese women should, therefore, be given proper counselling regarding the negative impacts of over and underweight so that they can be aware and try controlling their weight before and/or throughout pregnancy period.

Based on nationally representative datasets, the presents study provides valuable insights on the current situation of LBW in selected African countries. To our knowledge, this is the most comprehensive study to focus on the association between maternal body weight status and birthweight outcomes among African women. Findings from this study are expected to assist future researches in this line and the policy makers to devise strategies or intervention programs to address the rising prevalence of LBW. Besides its scientific contributions, few important limitations need to be noted. A major barrier to measuring rates of LBW in developing countries is low prevalence of non-institutional delivery which increases the likelihood of not being weighed at birth. An estimated 75% of new-borns are not weighed sub-Saharan Africa, and therefore data on low birthweight may not be representative of the general population. Another limitation is that as pre-pregnancy BMI was not available, we used the BMI values taken during interview as a proxy and assumed the change as minimal or insignificant which could have impacted the outcome to some degree. However previous studies have adopted post-gestational BMI a predictor of LBW. It is recommended for future studies to focus on pre-gestational BMI and investigate if low BMI is the result of any other illness conditions. Also, the data being cross-sectional study, no causal relationship can be established between the explanatory and response variables.

Conclusion

This study concludes that the rate of low-birthweight remains high and prevalence has been on the rise for some countries during last decade. Women who are underweight are at increased risk of having low-birthweight babies in Sub-Saharan African countries. In light of the findings it is recommended to take special policy measures to promote universal access to antenatal care attendance among pregnant mothers and provide nutrition counselling at the same time. Integrating the provision of supplements/nutritious foods programs during pregnancy could benefit national low-birthweight related programs.

Abbreviations:

ANC: Antenatal care

DHS: Demographic and health survey

LBW: Low-birthweight

LMICs: Low-and-middle income countries

WHO: World Health Organization

Declarations

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Conflict of interest: Authors have no conflicts of interest to declare.

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Prevalence of low-birthweight and its association with maternal body weight status in selected countries in Africa: a cross-sectional study

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Abstract

Objective: The present study aimed to estimate the prevalence of Low Birth Weight (LBW), and to investigate the association between maternal body weight measured in terms of BMI and birthweight in selected countries in Africa.

Setting: Urban and rural household in Burkina Faso, Ghana, Malawi, Senegal, and Uganda.

Participants: Mothers (n=11,418) aged between 15 and 49 years with a history of childbirth in last five years.

Results: Prevalence of LBW in Burkina Faso, Ghana, Malawi, Senegal and Uganda was respectively 13.4%, 10.2%, 12.1%, 15.7%, and 10%. Compared to women who are normal weight, underweight mothers had a higher likelihood of giving birth to LBW babies in all countries except for in Ghana. However, the association between maternal BMI and birthweight was found to be statistically significant for Senegal only [OR=1.961 (1,259-3.055)].

Conclusion: Underweight mothers in Senegal share a greater risk of having low birthweight babies compared to their normal weight counterparts. Programs targeting to address infant mortality should focus on promoting nutritional status among women of childbearing age. Longitudinal studies are required to better elucidate the causal nature of the relationship between maternal underweight and LBW.

Keywords: Body mass index, Low birth weight, Maternal underweight, Neonatal mortality, Sub-Saharan Africa.

Strengths and limitations of this study

1. Based on nationally representative samples, this is first study to explore the association between maternal BMI and LBW across five different countries in Africa. The relatively large sample size provides a robust precision of the estimation

2. This study also provides an update on maternal BMI and LBW scenario, and reports the comparison of prevalence rates of these two important health indicators in these countries.

3. Owing to data constraints, some relevant sociocultural factors that could have affected the association were not included in the analysis.

4. The cross-sectional nature of the data prevents making any causal relationships.

Introduction

Last few decades have experienced an appreciable reduction in the burden of infant mortality rates (IMR) thanks to the programmatic efforts within the framework of Millennium Development Goals (MDGs).[1] Between 1990 and 2013, the rate of under-five mortality has declined by about half at global level (90% in 1990 vs 46% in 2013 per 1,000 live births).[1] Despite this progress in terms of total child mortality, the prevalence of neonatal mortality is still on the rise (38% in 2000 vs 45% in 2015), which poses significant barriers to the fulfilment of the MDGs.[2] Globally, preterm birth (28%), severe infections (26%), and asphyxia (23%) constitute the most important causes of neonatal death.[2, 3] However low–birthweight (weighing <2500g at birth) is also considered a crucial underlying determinant and contributor to neonatal and infant mortality.[3, 4] LBW accounts nearly half of all perinatal and one-third of all infant deaths.[5] Compared to normal birth weight (NBW) babies, LBW babies are 40 times more likely to die within first thirty days of life.[5] In African countries, low birth weight is claimed to be the strongest predictor of infant morbidity and mortality.[6] Given its critical importance on child survival, LBW was adopted as one of a number of health indicators as part of the global strategy for health in the 34th assembly of World Health Organization (WHO) in 2000.[7]

Regional statistics suggest that the global burden of neonatal mortality is heavily skewed towards developing countries which account for nearly all LBW cases.[5] According to WHO estimates, out of more than 20 million LBW babies (representing 15.5% of all live births) nearly 95.6% takes place in the low-and-middle income countries (LMICs).[5] Evidence from South Asian countries, highest LBW prevalent global region, shows that majority of the neonatal death occurred among those who weighed less than 2500g at birth (54% in Pakistan and 79.5% in India).[4, 8] Apart from the higher likelihood of neonatal mortality, LBW babies in later periods of life face greater risks of poor cognitive development, impaired immunity, developing chronic medical conditions and neurodegenerative diseases.[9-11] Besides its direct consequences on physical and mental health, LBW has important socioeconomic bearings e.g. low workplace productivity, increased spending on healthcare with adverse impacts on national development imperatives in the aggregate.[10-12] Besides being a significant determinant of the chances for survival and long-term health status of infants, LBW also serves as an indicator of health, nutritional and socioeconomic status of the mother.[13, 14]

There exists a number of studies that have attempted to identify the causes of LBW and have shown that the factors fall into a diversity of socioeconomic, biological, psychological, and nutrition-related factors.[10-16] The themes that commonly emerge from the previous studies include maternal height and weight, level of education, socioeconomic status, adherence to adequate antenatal care services, order and number pregnancies.[15-18] Research evidence on the association between maternal BMI and LBW can be useful in informing policy making and health promotion programs. Unfortunately, most of the countries lack a well-developed birth registry system which poses challenges for conducting researches on nationally representative sample. However, only a handful of the studies are based on country representative population, and results remain mixed. To address this data and research gap, we used secondary datasets from DHS which collects representative data on various anthropometric and socioeconomic indicators on individual women and their children. Our main goal in this study was to assess whether or not maternal BMI had any relationship with birthweight.

Methods

Study setting, sampling and data collection

The study is based on cross-sectional data on individual women collected from recent Demographic and Health Surveys (DHS) in five Sub-Saharan countries: Burkina Faso, Ghana, Malawi, Senegal, and Uganda. Details about the year, implementing body and response rates are listed in **Table 1**. DHS surveys operate in developing countries with an aim to conduct quality studies on basic demographic and health indicators on under-five children, men (aged 18 to 59) and women (aged 18 to 49). Among many, the dominant themes of the surveys include childhood mortality, family planning and fertility, maternal and child health, nutrition, health-related knowledge and behaviour.[19] The main objectives of the program are to provide quality data on public health issues and increased dissemination and utilization of the data to promote evidence-based health policy-making.[19] DHS programs work in collaboration with local and international development partners to implement the survey programs with financial support from the United States Agency for International Development (USAID) and technical assistance by ICF International.

The surveys collect information by using standardized questionnaires on various themes on eligible samples and other members of the households. For sampling, DHS employs a two-stage cluster design of the population which involves labelling the smallest administrative units as enumeration areas (EAs) or clusters. Selection of EAs is based on their size proportional to that of the units. In the second step, households are selected systematically from each EA to ensure effective sampling. DHS provides no exact information on the spatial dimension of EAs. However, it consists about hundred to 30 thousand households varying from country to country. Detailed versions of sampling procedure are published in previous studies.[20, 21]

Table 1. Description of the surveys for the countries and included in the study

Country	Survey Round	Implementing body	Year	Sample (Response rate %)
Burkina Faso	VI	Institut National de la Statistique et de la Démographie	May 2010 -January, 2011	17,087 (98.4)
Ghana	VII	Ghana Statistical Service (GSS), the Ghana Health Service (GHS)	January-March, 2014.	9,396 (97.3)
Malawi	VI	National Statistical Office of Malawi (NSO)	June- November, 2010	23,020 (96.9)
Senegal	VI	Agence Nationale de la Statistique et de la Démographie (ANSD)	2010-11,	15,688 (92.7)
Uganda	VI	Uganda Bureau of Statistics (UBOS)	June- December 2011	8,674 (93.8)

Participants: Mother of at least one child ageing between 15 and 49 years and living in non-institutional residences in: Burkina Faso, Ghana, Malawi, Senegal, and Uganda.

Variables

Dependent variable: The dependent variable in this study was birth weight for the most recent child. As per WHO classification, birth weight was categorized as low birth weight (LBW) < 2500gm and normal birth weight (NBW) ≥2500gm.

Explanatory variable: The main explanatory variable was pre-pregnancy body weight status of the respondents measured in terms of BMI. During the interviews, height and weight were measured by standard anthropometric procedures for those who were eligible and gave consent. As per WHO recommendation, BMI was categorized in the following way: Underweight (<18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight & obese (≥25kg/m^2).

Covariates: Demographic and socioeconomic variables that could influence the associations between maternal BMI and LBW were included in the multivariable analyses. Based on the insights from literature review, and availability on the datasets, the following variables were included as potential confounders in this study: Maternal age; Area of residence: urban/ rural; Educational attainment: Nil/primary/secondary& higher; Household wealth status*: poorest, poorer, middle, richer and richest; parity: $<3/\geq3$; ANC**: $<4/\geq4$; Pregnancy wantedness (most recent pregnancy): Yes/no.

*As DHS do not collect data on individual income, this study used household wealth index as a proxy for economic status. It is calculated based on factors scores generated by principal component analysis on of ownership of household assets e.g. source of drinking water, type of toilet facility, type of cooking fuel, ownership of TV, refrigerator. Based on individual scores households fall into five categories on the wealth index: poorest, poorer, middle, richer and richest.[22]

**The World Health Organization (WHO) recommends at least four ANC visits during the course of normal pregnancies.

Data analysis

Data were analyzed using SPSS® version 22. Respondents for whom there was no information on height or weight were excluded from the analysis. Basic characteristics of the sample, including the prevalence rates were presented as frequencies and percentages. Since the dependent variable was dichotomous in nature, a binary logistic regression technique was performed to examine the association between maternal BMI and LBW. Separate bivariate and multivariate models were run for each country included in the analysis. Each of the background variable that showed a significance level of 0·25 in the bivariate analysis (as proposed by Hosmer and Lemeshaw) were retained for multivariable analysis.[23] To adjust for the clustered nature of the data, we used binary logistic technique from the generalized estimating equations.[24] Results of multivariate analysis were presented as Odds Ratios and 95 % confidence intervals. Before regression analysis, variance inflation factor (VIF) was used to check for collinearity and to ensure that the assumptions of multi-collinearity were not violated. All statistical tests were two-tailed and a $p < 0.05$ was considered statistically significant.

Patient and Public Involvement: Not applicable for this study.

Results

Sample characteristics

The basic socio-demographic characteristics of the sample population for individual countries are presented in **Table 2** and **3**. Results indicate that average age was lowest at 28.1 years for Malawi and highest at 30.34 years for Ghana (SD 6.63). Women from all countries were predominantly rural origin and the percentage ranged from 86.8% in Malawi to 57.1% in Ghana. Regarding educational status, Malawi had the highest literacy rate (86.7%) followed by Uganda (83.7%) and Ghana (75.1%). The majority of the women in all countries reported living in poorest to middle wealth status households. Percentage of participants from richest wealth status was highest for Burkina Faso (24.1%) and lowest for Senegal (13.5%). Women in Burkina Faso had the highest parity (62.2%) with the majority of the women in Ghana, Malawi and Uganda had given birth to less than three children. The rate of the antenatal visit for last pregnancy was low in all the countries ranging from over a quarter in Senegal (27.3%) to about three-fifth in (59.9%) in Burkina Faso. Well above half of the women in Ghana (71.4%) and Uganda (54.4%) reported their last pregnancy as unintended.

Prevalence data

Prevalence of underweight among women was highest for Senegal (16.1%) and lowest for Malawi (5.9%) and that of overweight was lowest for Ghana (41.9%) and lowest for Burkina Faso (11.3%). Prevalence of underweight was highest in Senegal (15%) followed by Ghana (10.4%) and Malawi (10.1%) and was lowest in Uganda (5.3%). Mean birth weight in Burkina Faso, Ghana, Malawi, Senegal and Uganda were respectively 2.97 (0.52), 3.25 (0.7), 3 (0.7), 3.35 (0.48). That of LBW was 13.4%, 10.2%, 12.1%, 15.7%, 10 % in the abovementioned order (Table 3).

Table 2. Basic socio-demographic characteristics of the study sample by country

Variables	**Burkina Faso** (N=3743)	**Ghana** (N=1338)	**Malawi** (N=3113)	**Senegal** (N=1665)	**Uganda** (N=1559)
Age Mean (SD)	29.09 (7.1)	30.34 (6.63)	28.1 (6.86)	28.93 (9.21)	28.78 (7.08)
Region					
Urban	30.9	46.4	13.2	42.9	18.8
Rural	69.1	53.6	86.8	57.1	81.2
Education					
Nil	75.7	24.9	12.3	62.2	16.3
Primary	15.4	18.5	67.9	25.8	58.9
Secondary/Higher	8.8	56.6	19.8	12.1	24.8
Wealth index					
Poorest	13.7	23.2	17.3	23.5	23.9
Poorer	17.1	16.6	19.7	24.6	18.9
Middle	20.8	21.4	22.3	20.2	16.5
Richer	24.4	19.7	21.7	18.2	17.0
Richest	24.1	19.1	19.0	13.5	23.7
Parity					
<3	37.8	52.7	61.0	45.2	53.7
≥3	62.2	47.3	39.0	54.8	46.3
ANC					
<4	59.9	6.7	52.8	27.6	47.7
≥4	40.1	93.3	47.2	72.4	52.3
Last pregnancy intended					
Yes	89.3	28.6	46.0	61.0	45.2
No	10.7	71.4	54.0	39.0	54.8
BMI					
Underweight	11.0	4.5	5.9	16.1	10.2
Overweight/Obese	11.3	41.9	17.6	21.5	19.4
Normal weight	77.7	53.7	76.5	62.4	70.4

N.B. ANC= Antenatal Care, BMI=Body mass index. Except for age, the numbers represent percentages.

Figure 1

Results of chi-square tests are shown in Table 3. It shows that mothers ageing more than 35 years, being of rural origin, having to formal education, living in poorer to poorest wealth status were more likely to give birth to LBW babies. The likelihood of having LBW babies were also higher among those with lesser parity, attending less than four ANC visits, and reported last pregnancy as unintended. Underweight mothers had a higher likelihood of having LBW babies compared to overweight/obese mothers in all countries but Uganda ($p>0.05$).

Table 3. Percentage of LBW babies across maternal socioeconomic and BMI status

Variables	Burkina Faso(13.4%)	Ghana (10.2%)	Malawi (12.1%)	Senegal (15.7%)	Uganda (10 %)
Age					
<35	79.6	79.1	78.7	22.9	15.7
35+	20.4	20.9	21.3	77.1	84.3
p	0.025	0.016	0.124	0.030	0.001
Region					
Urban	31.1	48.2	14.0	46.2	44.6
Rural	68.9	51.8	86.0	53.8	55.4
p	0.479	0.360	0.356	0.000	0.003
Education					
Nil	78.1	22.3	15.6	68.3	13.3
Primary	14.4	19.4	69.5	22.1	48.2
Secondary/Higher	7.5	58.3	14.9	9.6	38.6
p	0.179	0.158	0.024	0.000	0.013
Wealth index					
Richest	13.1	14.4	14.6	14.1	21.7
Richer	16.1	12.9	21.6	20.5	9.6
Middle	23.8	18.0	21.9	22.5	12.0
Poorer	25.3	25.2	22.2	18.5	21.7
Poorest	21.7	29.5	19.7	24.5	34.9

p	0.168	0.041	0.149	0.209	0.027
Parity					
<3	46.6	45.3	44.4	43.4	39.8
≥3	53.4	54.7	55.6	56.6	60.2
p	0.001	0.04	0.021	0.253	0.385
ANC					
<4	59.9	9.4	58.7	26.5	45.8
≥4	40.1	90.6	41.3	73.5	54.2
p	0.136	0.123	0.015	0.113	0.000
Last pregnancy intended					
Yes	10.7	25.9	47.0	61.0	49.4
No	89.3	74.1	53.0	39.0	50.6
p	0.251	0.139	0.173		0.000
BMI					
Underweight	13.5	36.0	14.9	21.7	19.3
Overweight/Obese	9.9	5.0	8.3	9.2	7.2
Normal weight	76.6	59.0	76.8	69.2	73.5
p	0.018	0.04	0.000	0.019	0.116

N.B. p-value from chi-square test. ANC= Antenatal Care, BMI=Body mass index.

Association between maternal body mass index and LBW.

Results of multivariable logistic regression are presented in table 4 and table 5. Among underweight mothers compared to normal weight, the odds of having LBW babies were respectively 1.29, 1.45, 1.50 times higher in Burkina Faso, Malawi, and Uganda. The odds of having LBW babies were statistically significant among underweight mothers in Senegal only.

As shown in table 5, the nature of the association between maternal BMI and LBW remained nearly the same for all the countries after adjusting for other variables in the models. Compared to normal weight mothers, underweight mothers in all five countries had higher odds of having LBW babies, however the association was statistically significant for Senegal only.

For sensitivity analysis, we performed the regression analysis with different combinations of explanatory variables (not shown), and calculated crude odds ratio. The results did not show any significant deviation from the final analysis.

Table 4. Association (Crude) between maternal BMI and LBW, in selected countries in Africa

	Burkina Faso	Ghana	Malawi	Senegal	Uganda
Birth weight Normal	-	-	-	-	-
Underweight	1.298 (0.977-1.724)	1.026 (0.460-2.286)	1.454 (0.948-2.230)	1.909 (1.242-2.933)	1.501 (0.652-3.457)
Overweight	0.870 (0.629-1.203)	0.763 (0.522-1.116)	0.972 (0.593-1.154)	1.048 (0.753-1.457)	1.156 (0.602-1.854)

N.B. Reference category is NBW. Confidence intervals (95%) shown in parenthesis.

Table 5. Association (Adjusted) between maternal BMI and LBW in selected countries in Africa

	Burkina Faso	Ghana	Malawi	Senegal	Uganda
Birth weight Normal	-	-	-	-	-
Underweight	1.304 (0.974-1.745)	1.030 (0.453-2.342)	1.449 (0.936-2.242)	1.961 (1,259-3.055)	1.363 (0.587-3.169)
Overweight	0.933 (0.676-1.343)	0.780 (0.533-1.141)	0.998 (0.638-1.265)	1.088 (0.774-1.530)	1.065 (0.526-1.129)

N.B. Regression model adjusted for all the socio-demographic variables which showed significant association p<0.25 in cross-tabs.

Discussion and policy recommendation

Our findings showed considerable variations in the prevalence of BMI and birthweight among the five countries. Percentage of women who were underweight was highest in

Senegal and lowest in Ghana, whereas that of overweight was highest in Ghana and lowest in Burkina Faso. Mean birth weight was highest Uganda, and lowest in Burkina Faso. The prevalence of LBW ranged from 10% in Uganda to 15.7% in Senegal. Besides the inter-country differences, the prevalence of LBW varied within countries as well, with the prevalence being higher in rural women compared with urban women. The likelihood of having LBW babies were higher among women with lower parity, attending less than four ANC visits, and reported last pregnancy as unintended. Underweight mothers had a higher likelihood of having LBW babies compared to overweight/obese mothers.

The rate of LBW for the countries included in this study were found to be similar to regional estimate of 13%, lower than in south Asia 28% and global average for developing countries 16.5%.[25, 26] However, the level is still twice as high compared to developed country average 7%.[26] Countries in Sub-Saharan Africa rank second in terms of the prevalence of LBW after South Asia. As seen at the global level, the rate of progress towards MDGs has been uneven across the countries included in this study. Among the five countries we studied, only Burkina Faso experienced some reduction in the prevalence of LBW during the last decade 18% in 2003 vs 13.4% in 2010-11.[27] For Ghana and Malawi, the situation has worsened considerably since their previous estimates (2% in 2003 Vs 10.2 in 2014) for Ghana, and (5% in 2000 Vs 10 % in 2010).[28, 29]

The rise in the burden of LBW in these countries serves as an indication of a poor/inadequate implementation of national health policies to realise the MDG goals targeted at improving child health outcomes (MDG 4 and 5). This deserves special research attention delving into the underlying causes of the rise in LBW prevalence and call for employing more robust policy agenda to reverse the situation. A commonly proposed strategy to prevent maternal and childbirth-related complications is to take early precaution by providing necessary care for pregnant mothers through antenatal care services. Our results show that the rate of ANC attendance was very low for all the countries. National LBW prevention policies should also focus on strategies to improve ANC visits among mothers, particularly in the rural areas. Besides that, ANC visits have found to be effective in encouraging institutional deliveries which itself reduces the risk of birth-related complications and increases the rate of weighing at birth and thus helps in better monitoring of LBW rates. In Uganda, for instance, the majority of births (about 70%) during the five years preceding the survey were not weighed.[30] This is understandable given that fact that only 37 % of total childbirths have taken place in a health facility.

In line with past findings, our results showed that mothers who were underweight were at higher risk of having low birth weight babies compared with normal weight mothers. Previously, a systematic review including 42 studies found that both in developed and developing countries children born to underweight mother were at higher risk of being low birthweight compared with those born to women with normal weight.[31] This finding was supported by a recent meta-analysis in the context of low-and-middle-income countries: low birthweight was significantly associated with maternal underweight, but not maternal overweight/obesity.[32] These findings warrant for strong policy attention to address under-nutrition among mothers especially because of its intergenerational effects. Though the situation has seen some progress during last 8-10 years, about 5 to 20% women in Africa still suffer from maternal malnutrition due to chronic hunger with adverse consequences on birthweight and infant and maternal mortality.[33] The rate of underweight has declined for Burkina Faso from 20.9% in 2003 in to 11% in 2010-11, Ghana from 9% in 2003 to 4.5% in 2014, Malawi from 9% in 2000 to 5.9% in 2010, Senegal from 21% in 2005 to 16.1% in 2010-11.[27-29] For Uganda however no visible progress has been achieved since 2010 (10.4% in 2000-01 to 10.2% in 2011).[30] As under-nutrition itself is a multifactorial problem, the solution will require developing cross-cutting policies and placing the issue on broad national health and development agenda.

Regarding the impact of overweight/obesity on birthweight outcomes on the other hand, current research evidences are still not sufficiently clear and varies across and within countries. Notably, finding of the present study suggest a protective effect of overweight/obesity on LBW among Ghana and Malawian women. This finding is consistent with an Indian study based on National Family Health Survey NFHS 2, 1998-99.[34] This finding was supported by another conducted in a different Asian setting reporting that the odds of having LBW babies were more than double in underweight women compared to non-obese women.[34] However, these findings conflict with one meta-analysis study which reported that maternal overweight/obesity was associated with lower risk of LBW in developing countries, but the effect did not remain effective after controlling for publication bias.[20] The protective effect of maternal overweight/obesity, however, should not be regarded as a recommendation since it is involved with a range of fetal growth and obstetric complications.[35, 36] Overweight/obese women should, therefore, be given proper counselling regarding the negative impacts of over and underweight so that they can be aware and try controlling their weight before and/or throughout pregnancy period.

Based on nationally representative datasets, the presents study provides valuable insights on the current situation of LBW in selected African countries. To our knowledge, this is the most comprehensive study to focus on the association between maternal body weight status and birthweight outcomes among African women. The surveys were country representative and hence the findings are generalisable for women aged 15-49 years. Findings from this study are expected to assist future researches in this line and the policy makers to devise strategies or intervention programs to address the rising prevalence of LBW. Besides its scientific contributions, few important limitations need to be noted. A major barrier to measuring rates of LBW in developing countries is low prevalence of non-institutional delivery which increases the likelihood of not being weighed at birth. An estimated 75% of new-borns are not weighed sub-Saharan Africa, and therefore data on low birthweight may not be representative of the general population. Another limitation is that as pre-pregnancy BMI was not available, we used the BMI values taken during interview as a proxy and assumed the change as minimal or insignificant which could have impacted the outcome to some degree. However previous studies have adopted post-gestational BMI a predictor of LBW. It is recommended for future studies to focus on pre-gestational BMI and investigate if low BMI is the result of any other illness conditions. Also, the data being cross-sectional study, no causal relationship can be established between the explanatory and response variables.

Conclusion

This study concludes that the rate of low-birthweight remains high and prevalence has been on the rise for some countries during last decade. Women who are underweight had increased odds of having low-birthweight babies in Senegal. In light of the findings it is recommended to take special policy measures to promote universal access to antenatal care attendance among pregnant mothers and provide nutrition counselling at the same time to reduce the burden the underweight. Integrating the provision of supplements/nutritious foods programs during pregnancy could benefit child nutrition and low-birthweight related programs.

Abbreviations

ANC: Antenatal care

DHS: Demographic and health survey

LBW: Low-birthweight

LMICs: Low-and-middle income countries

WHO: World Health Organization

Declarations

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Ethics approval: The protocol of DHS surveys was approved by the Ethics Committee of ORC Macro Inc. The study was based on analysis of anonymised secondary data available in the public domain of DHS, therefore no additional approval was necessary. However, approval for the reuse of the data was obtained by authors from DHS.

Conflict of interest: Authors have to conflict of interest to declare.

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Figure 1: Percentage of LBW babies in individual countries stratified by region

Figure 1 illustrates the percent distribution of LBW babies between urban and rural regions in the individual countries. It shows that prevalence of LBW was higher in rural areas for all countries. Regional difference in LBW prevalence was most noteworthy for Senegal.

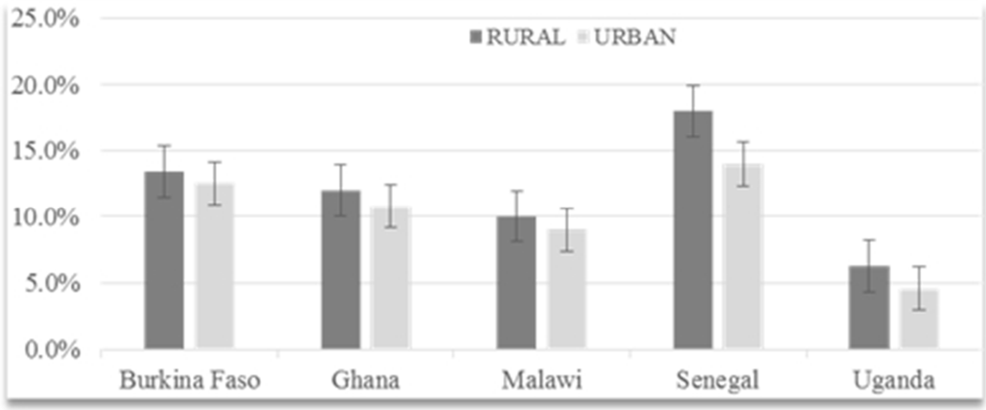

Figure 1 illustrates the percent distribution of LBW babies between urban and rural regions in the individual countries. It shows that prevalence of LBW was higher in rural areas for all countries. Regional difference in LBW prevalence was most noteworthy for Senegal.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract (Page 2)
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found (Page 2)
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported (Page 3)
Objectives	3	State specific objectives, including any prespecified hypotheses (3-4)
Methods		
Study design	4	Present key elements of study design early in the paper (Page 4)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection (Page 4-5)
Participants	6	*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants (Page 5)
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable (Page 6)
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 (Page 6-7)
Bias	9	Describe any efforts to address potential sources of bias (NA)
Study size	10	Explain how the study size was arrived at (Page 6)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why (Page 7)
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding (Page 7)
		(*b*) Describe any methods used to examine subgroups and interactions (Page 7)
		(*c*) Explain how missing data were addressed (NA)
		(*e*) Describe any sensitivity analyses (Page 12)

Continued on next page

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 (Page 8)
		(b) Give reasons for non-participation at each stage (NA)
		(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 (Page 8)
		(b) Indicate number of participants with missing data for each variable of interest (Page 8)
Outcome data	15*	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure (Page 8)
		Cross-sectional study—Report numbers of outcome events or summary measures
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 (Page 11-12)
		(*b*) Report category boundaries when continuous variables were categorized (NA)
		(*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 (Page 12)
Discussion		
Key results	18	Summarise key results with reference to study objectives (Page 13)
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 (Page 15-16)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence (Page 14-15)
Generalisability	21	Discuss the generalisability (external validity) of the study results (Page 15)
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. (Page 17)

*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.

Prevalence of low-birthweight and its association with maternal body weight status in selected countries in Africa: a cross-sectional study

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Prevalence of low-birthweight and its association with maternal body weight status in selected countries in Africa: a cross-sectional study

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Abstract

Objective: The present study aimed to estimate the prevalence of Low Birth Weight (LBW), and to investigate the association between maternal body weight measured in terms of BMI and birthweight in selected countries in Africa.

Setting: Urban and rural household in Burkina Faso, Ghana, Malawi, Senegal, and Uganda.

Participants: Mothers (n=11,418) aged between 15 and 49 years with a history of childbirth in last five years.

Results: Prevalence of LBW in Burkina Faso, Ghana, Malawi, Senegal and Uganda was respectively 13.4%, 10.2%, 12.1%, 15.7%, and 10%. Compared to women who are normal weight, underweight mothers had a higher likelihood of giving birth to LBW babies in all countries except for in Ghana. However, the association between maternal BMI and birthweight was found to be statistically significant for Senegal only [OR=1.961 (1,259-3.055)].

Conclusion: Underweight mothers in Senegal share a greater risk of having low birthweight babies compared to their normal weight counterparts. Programs targeting to address infant mortality should focus on promoting nutritional status among women of childbearing age. Longitudinal studies are required to better elucidate the causal nature of the relationship between maternal underweight and LBW.

Keywords: Body mass index, Low birth weight, Maternal underweight, Neonatal mortality, Sub-Saharan Africa.

Strengths and limitations of this study

1. Based on nationally representative samples, this is first study to explore the association between maternal BMI and LBW across five different countries in Africa. The relatively large sample size provides a robust precision of the estimation

2. This study also provides an update on maternal BMI and LBW scenario, and reports the comparison of prevalence rates of these two important health indicators in these countries.

3. Owing to data constraints, some relevant sociocultural factors that could have affected the association were not included in the analysis.

4. The cross-sectional nature of the data prevents making any causal relationships.

Introduction

Last few decades have experienced an appreciable reduction in the burden of infant mortality rates (IMR) thanks to the programmatic efforts within the framework of Millennium Development Goals (MDGs).[1] Between 1990 and 2013, the rate of under-five mortality has declined by about half at global level (90% in 1990 vs 46% in 2013 per 1,000 live births).[1] Despite this progress in terms of total child mortality, the prevalence of neonatal mortality is still on the rise (38% in 2000 vs 45% in 2015), which poses significant barriers to the fulfilment of the MDGs.[2] Globally, preterm birth (28%), severe infections (26%), and asphyxia (23%) constitute the most important causes of neonatal death.[2, 3] However low–birthweight (weighing <2500g at birth) is also considered a crucial underlying determinant and contributor to neonatal and infant mortality.[3, 4] LBW accounts nearly half of all perinatal and one-third of all infant deaths.[5] Compared to normal birth weight (NBW) babies, LBW babies are 40 times more likely to die within first thirty days of life.[5] In African countries, low birth weight is claimed to be the strongest predictor of infant morbidity and mortality.[6] Given its critical importance on child survival, LBW was adopted as one of a number of health indicators as part of the global strategy for health in the 34th assembly of World Health Organization (WHO) in 2000.[7]

Regional statistics suggest that the global burden of neonatal mortality is heavily skewed towards developing countries which account for nearly all LBW cases.[5] According to WHO estimates, out of more than 20 million LBW babies (representing 15.5% of all live births) nearly 95.6% takes place in the low-and-middle income countries (LMICs).[5] Evidence from South Asian countries, highest LBW prevalent global region, shows that majority of the neonatal death occurred among those who weighed less than 2500g at birth (54% in Pakistan and 79.5% in India).[4, 8] Apart from the higher likelihood of neonatal mortality, LBW babies in later periods of life face greater risks of poor cognitive development, impaired immunity, developing chronic medical conditions and neurodegenerative diseases.[9-11] Besides its direct consequences on physical and mental health, LBW has important socioeconomic bearings e.g. low workplace productivity, increased spending on healthcare with adverse impacts on national development imperatives in the aggregate.[10-12] Besides being a significant determinant of the chances for survival and long-term health status of infants, LBW also serves as an indicator of health, nutritional and socioeconomic status of the mother.[13, 14]

There exists a number of studies that have attempted to identify the causes of LBW and have shown that the factors fall into a diversity of socioeconomic, biological, psychological, and nutrition-related factors.[10-16] The themes that commonly emerge from the previous studies include maternal height and weight, level of education, socioeconomic status, adherence to adequate antenatal care services, order and number pregnancies.[15-18] Research evidence on the association between maternal BMI and LBW can be useful in informing policy making and health promotion programs. Unfortunately, most of the countries lack a well-developed birth registry system which poses challenges for conducting researches on nationally representative sample. However, only a handful of the studies are based on country representative population, and results remain mixed.

To address this data and research gap, we used secondary datasets from DHS which collects representative data on various anthropometric and socioeconomic indicators on individual women and their children. The goals were to measure the prevalence of LBW in selected countries in Africa including Burkina Faso, Ghana, Malawi, Senegal, Uganda, as well as to investigate whether maternal body weight (measured in terms of BMI) has any influence on birthweight outcomes.

Methods

Study setting, sampling and data collection

The study is based on cross-sectional data on individual women collected from recent Demographic and Health Surveys (DHS) in five Sub-Saharan countries: Burkina Faso, Ghana, Malawi, Senegal, and Uganda. Details about the year, implementing body and response rates are listed in **Table 1**. DHS surveys operate in developing countries with an aim to conduct quality studies on basic demographic and health indicators on under-five children, men (aged 18 to 59) and women (aged 18 to 49). Among many, the dominant themes of the surveys include childhood mortality, family planning and fertility, maternal and child health, nutrition, health-related knowledge and behaviour.[19] The main objectives of the program are to provide quality data on public health issues and increased dissemination and utilization of the data to promote evidence-based health policy-making.[19] DHS programs work in collaboration with local and international development partners to implement the survey programs with financial support from the United States Agency for International Development (USAID) and technical assistance by ICF International.

The surveys collect information by using standardized questionnaires on various themes on eligible samples and other members of the households. For sampling, DHS employs a two-stage cluster design of the population which involves labelling the smallest administrative units as enumeration areas (EAs) or clusters. Selection of EAs is based on their size proportional to that of the units. In the second step, households are selected systematically from each EA to ensure effective sampling. DHS provides no exact information on the spatial dimension of EAs. However, it consists about hundred to 30 thousand households varying from country to country. Detailed versions of sampling procedure are published in previous studies.[20, 21]

Table 1. Description of the surveys for the countries and included in the study

Country	Survey Round	Implementing body	Year	Sample (Response rate %)
Burkina Faso	VI	Institut National de la Statistique et de la Démographie	May 2010 -January, 2011	17,087 (98.4)
Ghana	VII	Ghana Statistical Service (GSS), the Ghana Health Service (GHS)	January-March, 2014.	9,396 (97.3)
Malawi	VI	National Statistical Office of Malawi (NSO)	June- November, 2010	23,020 (96.9)
Senegal	VI	Agence Nationale de la Statistique et de la Démographie (ANSD)	2010-11,	15,688 (92.7)
Uganda	VI	Uganda Bureau of Statistics (UBOS)	June- December 2011	8,674 (93.8)

Participants: Mother of at least one child ageing between 15 and 49 years and living in non-institutional residences in: Burkina Faso, Ghana, Malawi, Senegal, and Uganda.

Variables

Dependent variable: The dependent variable in this study was birth weight for the most recent child. As per WHO classification, birth weight was categorized as low birth weight (LBW) < 2500gm and normal birth weight (NBW) ≥2500gm.

Explanatory variable: The main explanatory variable was pre-pregnancy body weight status of the respondents measured in terms of BMI. During the interviews, height and weight were measured by standard anthropometric procedures for those who were eligible and gave consent. As per WHO recommendation, BMI was categorized in the following way: Underweight (<18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight & obese (≥25kg/m^2).

Covariates: Demographic and socioeconomic variables that could influence the associations between maternal BMI and LBW were included in the multivariable analyses. Based on the insights from literature review, and availability on the datasets, the following variables were included as potential confounders in this study: Maternal age; Area of residence: urban/ rural; Educational attainment: Nil/primary/secondary& higher; Household wealth status*: poorest, poorer, middle, richer and richest; parity: <3/≥3; ANC**: <4/≥4; Pregnancy wantedness (most recent pregnancy): Yes/no.

*As DHS do not collect data on individual income, this study used household wealth index as a proxy for economic status. It is calculated based on factors scores generated by principal component analysis on of ownership of household assets e.g. source of drinking water, type of toilet facility, type of cooking fuel, ownership of TV, refrigerator. Based on individual scores households fall into five categories on the wealth index: poorest, poorer, middle, richer and richest.[22]

**The World Health Organization (WHO) recommends at least four ANC visits during the course of normal pregnancies.

Data analysis

Data were analyzed using SPSS® version 22. Respondents for whom there was no information on height or weight were excluded from the analysis. Basic characteristics of the sample, including the prevalence rates were presented as frequencies and percentages. Since the dependent variable was dichotomous in nature, a binary logistic regression technique was performed to examine the association between maternal BMI and LBW. Separate bivariate and multivariate models were run for each country included in the analysis. Each of the background variable that showed a significance level of 0·25 in the bivariate analysis (as proposed by Hosmer and Lemeshaw) were retained for multivariable analysis.[23] To adjust for the clustered nature of the data, we used binary logistic technique from the generalized estimating equations.[24] Results of multivariate analysis were presented as Odds Ratios and 95 % confidence intervals. Before regression analysis, variance inflation factor (VIF) was used to check for collinearity and to ensure that the assumptions of multi-collinearity were not violated. All statistical tests were two-tailed and a $p < 0.05$ was considered statistically significant.

Patient and Public Involvement: Not applicable for this study.

Results

Sample characteristics

The basic socio-demographic characteristics of the sample population for individual countries are presented in **Table 2** and **3**. Results indicate that average age was lowest at 28.1 years for Malawi and highest at 30.34 years for Ghana (SD 6.63). Women from all countries were predominantly rural origin and the percentage ranged from 86.8% in Malawi to 57.1% in Ghana. Regarding educational status, Malawi had the highest literacy rate (86.7%) followed by Uganda (83.7%) and Ghana (75.1%). The majority of the women in all countries reported living in poorest to middle wealth status households. Percentage of participants from richest wealth status was highest for Burkina Faso (24.1%) and lowest for Senegal (13.5%). Women in Burkina Faso had the highest parity (62.2%) with the majority of the women in Ghana, Malawi and Uganda had given birth to less than three children. The rate of the antenatal visit for last pregnancy was low in all the countries ranging from over a quarter in Senegal (27.3%) to about three-fifth in (59.9%) in Burkina Faso. Well above half of the women in Ghana (71.4%) and Uganda (54.4%) reported their last pregnancy as unintended.

Prevalence data

Prevalence of underweight among women was highest for Senegal (16.1%) and lowest for Malawi (5.9%) and that of overweight was lowest for Ghana (41.9%) and lowest for Burkina Faso (11.3%). Prevalence of underweight was highest in Senegal (16.1%) followed by Ghana (10.4%) and Malawi (10.1%) and was lowest in Uganda (5.3%). Mean birth weight in Burkina Faso, Ghana, Malawi, Senegal and Uganda were respectively 2.97 (0.52), 3.25 (0.7), 3 (0.7), 3.35 (0.48). That of LBW was 13.4%, 10.2%, 12.1%, 15.7%, 10 % in the abovementioned order (Table 3).

Table 2. Basic socio-demographic characteristics of the study sample by country

Variables	**Burkina Faso** (N=3743)	**Ghana** (N=1338)	**Malawi** (N=3113)	**Senegal** (N=1665)	**Uganda** (N=1559)
Age Mean (SD)	29.09 (7.1)	30.34 (6.63)	28.1 (6.86)	28.93 (9.21)	28.78 (7.08)
Region					
Urban	30.9	46.4	13.2	42.9	18.8
Rural	69.1	53.6	86.8	57.1	81.2
Education					
Nil	75.7	24.9	12.3	62.2	16.3
Primary	15.4	18.5	67.9	25.8	58.9
Secondary/Higher	8.8	56.6	19.8	12.1	24.8
Wealth index					
Poorest	13.7	23.2	17.3	23.5	23.9
Poorer	17.1	16.6	19.7	24.6	18.9
Middle	20.8	21.4	22.3	20.2	16.5
Richer	24.4	19.7	21.7	18.2	17.0
Richest	24.1	19.1	19.0	13.5	23.7
Parity					
<3	37.8	52.7	61.0	45.2	53.7
≥3	62.2	47.3	39.0	54.8	46.3
ANC					
<4	59.9	6.7	52.8	27.6	47.7
≥4	40.1	93.3	47.2	72.4	52.3
Last pregnancy intended					
Yes	89.3	28.6	46.0	61.0	45.2
No	10.7	71.4	54.0	39.0	54.8
BMI					
Underweight	11.0	4.5	5.9	16.1	10.2

Overweight/Obese	11.3	41.9	17.6	21.5	19.4
Normal weight	77.7	53.7	76.5	62.4	70.4

N.B. ANC= Antenatal Care, BMI=Body mass index. Except for age, the numbers represent percentages.

Figure 1

Results of chi-square tests are shown in Table 3. It shows that mothers ageing more than 35 years, being of rural origin, having to formal education, living in poorer to poorest wealth status were more likely to give birth to LBW babies. The likelihood of having LBW babies were also higher among those with lesser parity, attending less than four ANC visits, and reported last pregnancy as unintended. Underweight mothers had a higher likelihood of having LBW babies compared to overweight/obese mothers in all countries but Uganda (p>0.05).

Table 3. Percentage of LBW babies across maternal socioeconomic and BMI status

Variables	Burkina Faso(13.4%)	Ghana (10.2%)	Malawi (12.1%)	Senegal (15.7%)	Uganda (10 %)
Age					
<35	79.6	79.1	78.7	22.9	15.7
35+	20.4	20.9	21.3	77.1	84.3
p	0.025	0.016	0.124	0.030	0.001
Region					
Urban	31.1	48.2	14.0	46.2	44.6
Rural	68.9	51.8	86.0	53.8	55.4
p	0.479	0.360	0.356	0.000	0.003
Education					
Nil	78.1	22.3	15.6	68.3	13.3
Primary	14.4	19.4	69.5	22.1	48.2
Secondary/Higher	7.5	58.3	14.9	9.6	38.6
p	0.179	0.158	0.024	0.000	0.013
Wealth index					

Richest	13.1	14.4	14.6	14.1	21.7
Richer	16.1	12.9	21.6	20.5	9.6
Middle	23.8	18.0	21.9	22.5	12.0
Poorer	25.3	25.2	22.2	18.5	21.7
Poorest	21.7	29.5	19.7	24.5	34.9
p	0.168	0.041	0.149	0.209	0.027
Parity					
<3	46.6	45.3	44.4	43.4	39.8
≥3	53.4	54.7	55.6	56.6	60.2
p	0.001	0.04	0.021	0.253	0.385
ANC					
<4	59.9	9.4	58.7	26.5	45.8
≥4	40.1	90.6	41.3	73.5	54.2
p	0.136	0.123	0.015	0.113	0.000
Last pregnancy intended					
Yes	10.7	25.9	47.0	61.0	49.4
No	89.3	74.1	53.0	39.0	50.6
p	0.251	0.139	0.173		0.000
BMI					
Underweight	13.5	36.0	14.9	21.7	19.3
Overweight/Obese	9.9	5.0	8.3	9.2	7.2
Normal weight	76.6	59.0	76.8	69.2	73.5
p	0.018	0.04	0.000	0.019	0.116

N.B. p-value from chi-square test. ANC= Antenatal Care, BMI=Body mass index.

Association between maternal body mass index and LBW.

Results of multivariable logistic regression are presented in table 4 and table 5. Among underweight mothers compared to normal weight, the odds of having LBW babies were respectively 1.29, 1.45, 1.90, 1.50 times higher in Burkina Faso, Malawi, Senegal and Uganda. The odds of having LBW babies were statistically significant among underweight mothers in Senegal only.

As shown in table 5, the nature of the association between maternal BMI and LBW remained nearly the same for all the countries after adjusting for other variables in the models. Compared to normal weight mothers, underweight mothers in all five countries had higher odds of having LBW babies, however the association was statistically significant for Senegal only.

For sensitivity analysis, we performed the regression analysis with different combinations of explanatory variables (not shown), and calculated crude odds ratio. The results did not show any significant deviation from the final analysis.

Table 4. Association (Crude) between maternal BMI and LBW, in selected countries in Africa

	Burkina Faso	Ghana	Malawi	Senegal	Uganda
Birth weight					
Normal	1	1	1	1	1
Underweight	1.298 (0.977-1.724)	1.026 (0.460-2.286)	1.454 (0.948-2.230)	1.909 (1.242-2.933)	1.501 (0.652-3.457)
Overweight	0.870 (0.629-1.203)	0.763 (0.522-1.116)	0.972 (0.593-1.154)	1.048 (0.753-1.457)	1.156 (0.602-1.854)

N.B. Reference category is Normal Birth Weight. Confidence intervals (95%) shown in parenthesis.

Table 5. Association (Adjusted) between maternal BMI and LBW in selected countries in Africa

	Burkina Faso	Ghana	Malawi	Senegal	Uganda
Birth weight					
Normal	1	1	1	1	1
Underweight	1.304 (0.974-1.745)	1.030 (0.453-2.342)	1.449 (0.936-2.242)	1.961 (1,259-3.055)	1.363 (0.587-3.169)
Overweight	0.933 (0.676-1.343)	0.780 (0.533-1.141)	0.998 (0.638-1.265)	1.088 (0.774-1.530)	1.065 (0.526-1.129)

N.B. Regression model adjusted for all the socio-demographic variables which showed significant association p<0.25 in cross-tabs.

Discussion and policy recommendation

Our findings showed considerable variations in the prevalence of BMI and birthweight among the five countries. Percentage of women who were underweight was highest in Senegal and lowest in Ghana, whereas that of overweight was highest in Ghana and lowest in Burkina Faso. Mean birth weight was highest Uganda, and lowest in Burkina Faso. The prevalence of LBW ranged from 10% in Uganda to 15.7% in Senegal. Besides the inter-country differences, the prevalence of LBW varied within countries as well, with the prevalence being higher in rural women compared with urban women. The likelihood of having LBW babies were higher among women with lower parity, attending less than four ANC visits, and reported last pregnancy as unintended. Underweight mothers had a higher likelihood of having LBW babies compared to overweight/obese mothers, however the association was significant for Senegal only.

The rate of LBW for the countries included in this study were found to be similar to regional estimate of 13%, lower than in south Asia 28% and global average for developing countries 16.5%.[25, 26] However, the level is still twice as high compared to developed country average 7%.[26] Countries in Sub-Saharan Africa rank second in terms of the prevalence of LBW after South Asia. As seen at the global level, the rate of progress towards MDGs has been uneven across the countries included in this study. Among the five countries we studied, only Burkina Faso experienced some reduction in the prevalence of LBW during the last decade 18% in 2003 vs 13.4% in 2010-11.[27] For Ghana and Malawi, the situation has worsened considerably since their previous estimates (2% in 2003 Vs 10.2 in 2014) for Ghana, and (5% in 2000 Vs 10 % in 2010).[28, 29]

The rise in the burden of LBW in these countries serves as an indication of a poor/inadequate implementation of national health policies to realise the MDG goals targeted at improving child health outcomes (MDG 4 and 5). This deserves special research attention delving into the underlying causes of the rise in LBW prevalence and call for employing more robust policy agenda to reverse the situation. A commonly proposed strategy to prevent maternal and childbirth-related complications is to take early precaution by providing necessary care for pregnant mothers through antenatal care services. Our results show that the rate of ANC attendance was very low for all the countries. National LBW prevention policies should also focus on strategies to improve ANC visits among mothers, particularly in the rural areas. Besides that, ANC visits have found to be effective in encouraging institutional deliveries which itself reduces the risk of birth-related complications and increases the rate of weighing at birth and thus helps in better monitoring of LBW rates. In Uganda, for instance, the majority of births (about 70%) during the five years preceding the survey were not weighed.[30] This is understandable given that fact that only 37 % of total childbirths have taken place in a health facility.

In line with past findings, our results showed that mothers who were underweight were at higher risk of having low birth weight babies compared with normal weight mothers. Previously, a systematic review including 42 studies found that both in developed and developing countries children born to underweight mother were at higher risk of being low birthweight compared with those born to women with normal weight.[31] This finding was supported by a recent meta-analysis in the context of low-and-middle-income countries: low birthweight was significantly associated with maternal underweight, but not maternal overweight/obesity.[32] These findings warrant for strong policy attention to address under-nutrition among mothers especially because of its intergenerational effects. Though the situation has seen some progress during last 8-10 years, about 5 to 20% women in Africa still suffer from maternal malnutrition due to chronic hunger with adverse consequences on birthweight and infant and maternal mortality.[33] The rate of underweight has declined for Burkina Faso from 20.9% in 2003 in to 11% in 2010-11, Ghana from 9% in 2003 to 4.5% in 2014, Malawi from 9% in 2000 to 5.9% in 2010, Senegal from 21% in 2005 to 16.1% in 2010-11.[27-29] For Uganda however no visible progress has been achieved since 2010 (10.4% in 2000-01 to 10.2% in 2011).[30] As under-nutrition itself is a multifactorial problem, the solution will require developing cross-cutting policies and placing the issue on broad national health and development agenda.

Regarding the impact of overweight/obesity on birthweight outcomes on the other hand, current research evidences are still not sufficiently clear and varies across and within countries. Notably, finding of the present study suggest a protective effect of overweight/obesity on LBW among Ghana and Malawian women. This finding is consistent with an Indian study based on National Family Health Survey NFHS 2, 1998-99.[34] This finding was supported by another conducted in a different Asian setting reporting that the odds of having LBW babies were more than double in underweight women compared to non-obese women.[34] However, these findings conflict with one meta-analysis study which reported that maternal overweight/obesity was associated with lower risk of LBW in developing countries, but the effect did not remain effective after controlling for publication bias.[20] The protective effect of maternal overweight/obesity, however, should not be regarded as a recommendation since it is involved with a range of fetal growth and obstetric complications.[35, 36] Overweight/obese women should, therefore, be given proper counselling regarding the negative impacts of over and underweight so that they can be aware and try controlling their weight before and/or throughout pregnancy period.

Based on nationally representative datasets, the presents study provides valuable insights on the current situation of LBW in selected African countries. To our knowledge, this is the most comprehensive study to focus on the association between maternal body weight status and birthweight outcomes among African women. The surveys were country representative and hence the findings are generalisable for women aged 15-49 years. Findings from this study are expected to assist future researches in this line and the policy makers to devise strategies or intervention programs to address the rising prevalence of LBW. Besides its scientific contributions, few important limitations need to be noted. A major barrier to measuring rates of LBW in developing countries is low prevalence of non-institutional delivery which increases the likelihood of not being weighed at birth. An estimated 75% of new-borns are not weighed sub-Saharan Africa, and therefore data on low birthweight may not be representative of the general population. Another limitation is that as pre-pregnancy BMI was not available, we used the BMI values taken during interview as a proxy and assumed the change as minimal or insignificant which could have impacted the outcome to some degree. However previous studies have adopted post-gestational BMI a predictor of LBW. It is recommended for future studies to focus on pre-gestational BMI and investigate if low BMI is the result of any other illness conditions. Also, the data being cross-sectional study, no causal relationship can be established between the explanatory and response variables.

Conclusion

This study concludes that the rate of low-birthweight remains high and prevalence has been on the rise for some countries during last decade. Women who are underweight had increased odds of having low-birthweight babies, however the odds were statistically significant only for Senegal. In light of the findings it is recommended to take special policy measures to promote universal access to antenatal care attendance among pregnant mothers and provide nutrition counselling at the same time to reduce the burden the underweight. Integrating the provision of supplements/nutritious foods programs during pregnancy could benefit child nutrition and low-birthweight related programs.

Abbreviations

ANC: Antenatal care

DHS: Demographic and health survey

LBW: Low-birthweight

LMICs: Low-and-middle income countries

WHO: World Health Organization

Declarations

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Author contributions: ZFH，GB and YZ conceptualized the study and data collection. ZFH, GB, YS and YZ were responsible for data management and analysis. ZFH and GB contributed to initial drafting and interpretation of the results. DSZ, ZHC was responsible of the linguistic. All authors read the final manuscript and gave approval for publication.

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Ethics approval: The protocol of DHS surveys was approved by the Ethics Committee of ORC Macro Inc. The study was based on analysis of anonymised secondary data available in the public domain of DHS, therefore no additional approval was necessary. However, approval for the reuse of the data was obtained by authors from DHS.

Conflict of interest: Authors have to conflict of interest to declare.

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Figure 1: Percentage of LBW babies in individual countries stratified by region

Figure 1 illustrates the percent distribution of LBW babies between urban and rural regions in the individual countries. It shows that prevalence of LBW was higher in rural areas for all countries. Regional difference in LBW prevalence was most noteworthy for Senegal.

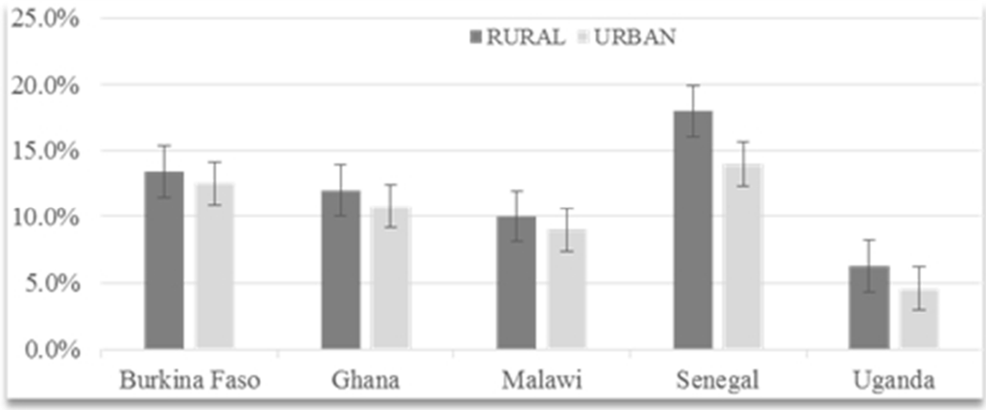

Figure 1 illustrates the percent distribution of LBW babies between urban and rural regions in the individual countries. It shows that prevalence of LBW was higher in rural areas for all countries. Regional difference in LBW prevalence was most noteworthy for Senegal.

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract (Page 2)
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found (Page 2)
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported (Page 3)
Objectives	3	State specific objectives, including any prespecified hypotheses (3-4)
Methods		
Study design	4	Present key elements of study design early in the paper (Page 4)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection (Page 4-5)
Participants	6	*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants (Page 5)
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable (Page 6)
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 (Page 6-7)
Bias	9	Describe any efforts to address potential sources of bias (NA)
Study size	10	Explain how the study size was arrived at (Page 6)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why (Page 7)
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding (Page 7)
		(*b*) Describe any methods used to examine subgroups and interactions (Page 7)
		(*c*) Explain how missing data were addressed (NA)
		(*e*) Describe any sensitivity analyses (Page 12)

Continued on next page

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 (Page 8)
		(b) Give reasons for non-participation at each stage (NA)
		(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 (Page 8)
		(b) Indicate number of participants with missing data for each variable of interest (Page 8)
Outcome data	15*	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure (Page 8)
		Cross-sectional study—Report numbers of outcome events or summary measures
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 (Page 11-12)
		(*b*) Report category boundaries when continuous variables were categorized (NA)
		(*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 (Page 12)
Discussion		
Key results	18	Summarise key results with reference to study objectives (Page 13)
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 (Page 15-16)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence (Page 14-15)
Generalisability	21	Discuss the generalisability (external validity) of the study results (Page 15)
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. (Page 17)

*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.

Prevalence of low-birthweight and its association with maternal body weight status in selected countries in Africa: a cross-sectional study

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Prevalence of low-birthweight and its association with maternal body weight status in selected countries in Africa: a cross-sectional study

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Abstract

Objective: The present study aimed to estimate the prevalence of Low Birth Weight (LBW), and to investigate the association between maternal body weight measured in terms of BMI and birthweight in selected countries in Africa.

Setting: Urban and rural household in Burkina Faso, Ghana, Malawi, Senegal, and Uganda.

Participants: Mothers (n=11,418) aged between 15 and 49 years with a history of childbirth in last five years.

Results: Prevalence of LBW in Burkina Faso, Ghana, Malawi, Senegal and Uganda was respectively 13.4%, 10.2%, 12.1%, 15.7%, and 10%. Compared to women who are normal weight, underweight mothers had a higher likelihood of giving birth to LBW babies in all countries except for in Ghana. However, the association between maternal BMI and birthweight was found to be statistically significant for Senegal only [OR=1.961 (1,259-3.055)].

Conclusion: Underweight mothers in Senegal share a greater risk of having low birthweight babies compared to their normal weight counterparts. Programs targeting to address infant mortality should focus on promoting nutritional status among women of childbearing age. Longitudinal studies are required to better elucidate the causal nature of the relationship between maternal underweight and LBW.

Keywords: Body mass index, Low birth weight, Maternal underweight, Neonatal mortality, Sub-Saharan Africa.

Strengths and limitations of this study

1. Based on nationally representative samples, this is first study to explore the association between maternal BMI and LBW across five different countries in Africa. The relatively large sample size provides a robust precision of the estimation

2. This study also provides an update on maternal BMI and LBW scenario, and reports the comparison of prevalence rates of these two important health indicators in these countries.

3. Owing to data constraints, some relevant sociocultural factors that could have affected the association were not included in the analysis.

4. The cross-sectional nature of the data prevents making any causal relationships.

Introduction

Last few decades have experienced an appreciable reduction in the burden of infant mortality rates (IMR) thanks to the programmatic efforts within the framework of Millennium Development Goals (MDGs).[1] Between 1990 and 2013, the rate of under-five mortality has declined by about half at global level (90% in 1990 vs 46% in 2013 per 1,000 live births).[1] Despite this progress in terms of total child mortality, the prevalence of neonatal mortality is still on the rise (38% in 2000 vs 45% in 2015), which poses significant barriers to the fulfilment of the MDGs.[2] Globally, preterm birth (28%), severe infections (26%), and asphyxia (23%) constitute the most important causes of neonatal death.[2, 3] However low–birthweight (weighing <2500g at birth) is also considered a crucial underlying determinant and contributor to neonatal and infant mortality.[3, 4] LBW accounts nearly half of all perinatal and one-third of all infant deaths.[5] Compared to normal birth weight (NBW) babies, LBW babies are 40 times more likely to die within first thirty days of life.[5] In African countries, low birth weight is claimed to be the strongest predictor of infant morbidity and mortality.[6] Given its critical importance on child survival, LBW was adopted as one of a number of health indicators as part of the global strategy for health in the 34th assembly of World Health Organization (WHO) in 2000.[7]

Regional statistics suggest that the global burden of neonatal mortality is heavily skewed towards developing countries which account for nearly all LBW cases.[5] According to WHO estimates, out of more than 20 million LBW babies (representing 15.5% of all live births) nearly 95.6% takes place in the low-and-middle income countries (LMICs).[5] Evidence from South Asian countries, highest LBW prevalent global region, shows that majority of the neonatal death occurred among those who weighed less than 2500g at birth (54% in Pakistan and 79.5% in India).[4, 8] Apart from the higher likelihood of neonatal mortality, LBW babies in later periods of life face greater risks of poor cognitive development, impaired immunity, developing chronic medical conditions and neurodegenerative diseases.[9-11] Besides its direct consequences on physical and mental health, LBW has important socioeconomic bearings e.g. low workplace productivity, increased spending on healthcare with adverse impacts on national development imperatives in the aggregate.[10-12] Besides being a significant determinant of the chances for survival and long-term health status of infants, LBW also serves as an indicator of health, nutritional and socioeconomic status of the mother.[13, 14]

There exists a number of studies that have attempted to identify the causes of LBW and have shown that the factors fall into a diversity of socioeconomic, biological, psychological, and nutrition-related factors.[10-16] The themes that commonly emerge from the previous studies include maternal height and weight, level of education, socioeconomic status, adherence to adequate antenatal care services, order and number pregnancies.[15-18] Research evidence on the association between maternal BMI and LBW can be useful in informing policy making and health promotion programs. Unfortunately, most of the countries lack a well-developed birth registry system which poses challenges for conducting researches on nationally representative sample. However, only a handful of the studies are based on country representative population, and results remain mixed.

To address this data and research gap, we used secondary datasets from DHS which collects representative data on various anthropometric and socioeconomic indicators on individual women and their children. The goals were to measure the prevalence of LBW in selected countries in Africa including Burkina Faso, Ghana, Malawi, Senegal, Uganda, as well as to investigate whether maternal body weight (measured in terms of BMI) has any influence on birthweight outcomes.

Methods

Study setting, sampling and data collection

The study is based on cross-sectional data on individual women collected from recent Demographic and Health Surveys (DHS) in five Sub-Saharan countries: Burkina Faso, Ghana, Malawi, Senegal, and Uganda. Details about the year, implementing body and response rates are listed in **Table 1**. DHS surveys operate in developing countries with an aim to conduct quality studies on basic demographic and health indicators on under-five children, men (aged 18 to 59) and women (aged 18 to 49). Among many, the dominant themes of the surveys include childhood mortality, family planning and fertility, maternal and child health, nutrition, health-related knowledge and behaviour.[19] The main objectives of the program are to provide quality data on public health issues and increased dissemination and utilization of the data to promote evidence-based health policy-making.[19] DHS programs work in collaboration with local and international development partners to implement the survey programs with financial support from the United States Agency for International Development (USAID) and technical assistance by ICF International.

The surveys collect information by using standardized questionnaires on various themes on eligible samples and other members of the households. For sampling, DHS employs a two-stage cluster design of the population which involves labelling the smallest administrative units as enumeration areas (EAs) or clusters. Selection of EAs is based on their size proportional to that of the units. In the second step, households are selected systematically from each EA to ensure effective sampling. DHS provides no exact information on the spatial dimension of EAs. However, it consists about hundred to 30 thousand households varying from country to country. Detailed versions of sampling procedure are published in previous studies.[20, 21]

Table 1. Description of the surveys for the countries and included in the study

Country	Survey Round	Implementing body	Year	Sample (Response rate %)
Burkina Faso	VI	Institut National de la Statistique et de la Démographie	May 2010 -January, 2011	17,087 (98.4)
Ghana	VII	Ghana Statistical Service (GSS), the Ghana Health Service (GHS)	January-March, 2014.	9,396 (97.3)
Malawi	VI	National Statistical Office of Malawi (NSO)	June- November, 2010	23,020 (96.9)
Senegal	VI	Agence Nationale de la Statistique et de la Démographie (ANSD)	2010-11,	15,688 (92.7)
Uganda	VI	Uganda Bureau of Statistics (UBOS)	June- December 2011	8,674 (93.8)

Participants: Mother of at least one child ageing between 15 and 49 years and living in non-institutional residences in: Burkina Faso, Ghana, Malawi, Senegal, and Uganda.

Variables

Dependent variable: The dependent variable in this study was birth weight for the most recent child. As per WHO classification, birth weight was categorized as low birth weight (LBW) < 2500gm and normal birth weight (NBW) ≥2500gm.

Explanatory variable: The main explanatory variable was pre-pregnancy body weight status of the respondents measured in terms of BMI. During the interviews, height and weight were measured by standard anthropometric procedures for those who were eligible and gave consent. As per WHO recommendation, BMI was categorized in the following way: Underweight (<18.5 kg/m^2), normal weight (18.5-24.9 kg/m^2), overweight & obese (≥25kg/m^2).

Covariates: Demographic and socioeconomic variables that could influence the associations between maternal BMI and LBW were included in the multivariable analyses. Based on the insights from literature review, and availability on the datasets, the following variables were included as potential confounders in this study: Maternal age; Area of residence: urban/ rural; Educational attainment: Nil/primary/secondary& higher; Household wealth status*: poorest, poorer, middle, richer and richest; parity: <3/≥3; ANC**: <4/≥4; Pregnancy wantedness (most recent pregnancy): Yes/no.

*As DHS do not collect data on individual income, this study used household wealth index as a proxy for economic status. It is calculated based on factors scores generated by principal component analysis on of ownership of household assets e.g. source of drinking water, type of toilet facility, type of cooking fuel, ownership of TV, refrigerator. Based on individual scores households fall into five categories on the wealth index: poorest, poorer, middle, richer and richest.[22]

**The World Health Organization (WHO) recommends at least four ANC visits during the course of normal pregnancies.

Data analysis

Data were analyzed using SPSS® version 22. Respondents for whom there was no information on height or weight were excluded from the analysis. Basic characteristics of the sample, including the prevalence rates were presented as frequencies and percentages. Since the dependent variable was dichotomous in nature, a binary logistic regression technique was performed to examine the association between maternal BMI and LBW. Separate bivariate and multivariate models were run for each country included in the analysis. Each of the background variable that showed a significance level of 0·25 in the bivariate analysis (as proposed by Hosmer and Lemeshaw) were retained for multivariable analysis.[23] To adjust for the clustered nature of the data, we used binary logistic technique from the generalized estimating equations.[24] Results of multivariate analysis were presented as Odds Ratios and 95 % confidence intervals. Before regression analysis, variance inflation factor (VIF) was used to check for collinearity and to ensure that the assumptions of multi-collinearity were not violated. All statistical tests were two-tailed and a $p < 0.05$ was considered statistically significant.

Patient and Public Involvement: Not applicable for this study.

Results

Sample characteristics

The basic socio-demographic characteristics of the sample population for individual countries are presented in **Figure1, Table 2** and **3**. Results indicate that average age was lowest at 28.1 years for Malawi and highest at 30.34 years for Ghana (SD 6.63). Women from all countries were predominantly rural origin and the percentage ranged from 86.8% in Malawi to 57.1% in Ghana. Regarding educational status, Malawi had the highest literacy rate (86.7%) followed by Uganda (83.7%) and Ghana (75.1%). The majority of the women in all countries reported living in poorest to middle wealth status households. Percentage of participants from richest wealth status was highest for Burkina Faso (24.1%) and lowest for Senegal (13.5%). Women in Burkina Faso had the highest parity (62.2%) with the majority of the women in Ghana, Malawi and Uganda had given birth to less than three children. The rate of the antenatal visit for last pregnancy was low in all the countries ranging from over a quarter in Senegal (27.3%) to about three-fifth in (59.9%) in Burkina Faso. Well above half of the women in Ghana (71.4%) and Uganda (54.4%) reported their last pregnancy as unintended.

Prevalence data

Prevalence of underweight among women was highest for Senegal (16.1%) and lowest for Malawi (5.9%) and that of overweight was lowest for Ghana (41.9%) and lowest for Burkina Faso (11.3%). Prevalence of underweight was highest in Senegal (16.1%) followed by Ghana (10.4%) and Malawi (10.1%) and was lowest in Uganda (5.3%). Mean birth weight in Burkina Faso, Ghana, Malawi, Senegal and Uganda were

210 respectively 2.97 (0.52), 3.25 (0.7), 3 (0.7), 3.35 (0.48). That of LBW was 13.4%, 10.2%,
211 12.1%, 15.7%, 10 % in the abovementioned order (Table 3).

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Table 2. Basic socio-demographic characteristics of the study sample by country

Variables	**Burkina Faso** (N=3743)	**Ghana** (N=1338)	**Malawi** (N=3113)	**Senegal** (N=1665)	**Uganda** (N=1559)
Age Mean (SD)	29.09 (7.1)	30.34 (6.63)	28.1 (6.86)	28.93 (9.21)	28.78 (7.08)
Region					
Urban	30.9	46.4	13.2	42.9	18.8
Rural	69.1	53.6	86.8	57.1	81.2
Education					
Nil	75.7	24.9	12.3	62.2	16.3
Primary	15.4	18.5	67.9	25.8	58.9
Secondary/Higher	8.8	56.6	19.8	12.1	24.8
Wealth index					
Poorest	13.7	23.2	17.3	23.5	23.9
Poorer	17.1	16.6	19.7	24.6	18.9
Middle	20.8	21.4	22.3	20.2	16.5
Richer	24.4	19.7	21.7	18.2	17.0
Richest	24.1	19.1	19.0	13.5	23.7
Parity					
<3	37.8	52.7	61.0	45.2	53.7
≥3	62.2	47.3	39.0	54.8	46.3
ANC					
<4	59.9	6.7	52.8	27.6	47.7
≥4	40.1	93.3	47.2	72.4	52.3
Last pregnancy intended					
Yes	89.3	28.6	46.0	61.0	45.2
No	10.7	71.4	54.0	39.0	54.8
BMI					
Underweight	11.0	4.5	5.9	16.1	10.2

Overweight/Obese	11.3	41.9	17.6	21.5	19.4
Normal weight	77.7	53.7	76.5	62.4	70.4

N.B. ANC= Antenatal Care, BMI=Body mass index. Except for age, the numbers represent percentages.

Results of chi-square tests are shown in Table 3. It shows that mothers ageing more than 35 years, being of rural origin, having to formal education, living in poorer to poorest wealth status were more likely to give birth to LBW babies. The likelihood of having LBW babies were also higher among those with lesser parity, attending less than four ANC visits, and reported last pregnancy as unintended. Underweight mothers had a higher likelihood of having LBW babies compared to overweight/obese mothers in all countries but Uganda (p>0.05).

Table 3. Distribution of LBW babies across maternal socioeconomic and BMI status

Variables	Burkina Faso (13.4%)	Ghana (10.2%)	Malawi (12.1%)	Senegal (15.7%)	Uganda (10 %)
Age					
<35	399 (79.6)	108 (79.4)	296 (78.7)	60 (22.9)	24 (15.4)
35+	102 (20.4)	28 (20.6)	80 (21.3)	201 (77.1)	132 (84.6)
p	0.025	0.016	0.124	0.030	0.001
Region					
Urban	156 (31.1)	66 (48.5)	53 (14.1)	121 (46.4)	70 (44.9)
Rural	345 (68.9)	70 (51.5)	323 (85.9)	140 (53.6)	86 (55.1)
p	0.479	0.360	0.356	0.000	0.003
Education					
Nil	391 (78.0)	30 (22.1)	59 (15.7)	178 (68.2)	21 (13.5)
Primary	72 (14.4)	27 (19.8)	261 (69.4)	58 (22.2)	75 (48.1)
Secondary/Higher	38 （7.6）	79 (58.1)	56 (14.9)	25 (9.6)	60 (38.5)
p	0.179	0.158	0.024	0.000	0.013
Wealth index					
Richest	66 (13.2)	20 (14.7)	55 (14.6)	37 (14.2)	34 (21.8)
Richer	81 (16.2)	18 (13.2)	81 (21.5)	54 (20.7)	15 (9.6)
Middle	119 (23.8)	24 (17.6)	82 (21.8)	59 (22.6)	19 (12.2)

Poorer	127 (25.3)	34 (25.0)	83 (22.1)	48 (18.4)	34 (21.8)
Poorest	108 (21.6)	40 (29.4)	75 (19.9)	63 (24.1)	54 (34.6)
p	0.168	0.041	0.149	0.209	0.027
Parity					
<3	233 (46.5)	62 (45.6)	167 (44.4)	113 (43.3)	62 (39.8)
≥3	268 (53.5)	74 (54.4)	209 (55.6)	148 (56.7)	94 (60.2)
p	0.001	0.04	0.021	0.253	0.385
ANC					
<4	300 (59.9)	13 (9.6)	221 (58.8)	69 (26.4)	71 (45.5)
≥4	201 (40.1)	123 (90.4)	155 (41.2)	192 (73.6)	85 (54.5)
p	0.136	0.123	0.015	0.113	0.000
Last pregnancy intended					
Yes	54 (10.8)	35 (25.7)	177 (47.1)	159 (61.9)	77 (49.4)
No	447 (89.2)	101 (74.3)	199 (52.9)	102 (39.1)	79 (50.6)
p	0.251	0.139	0.173		0.000
BMI					
Underweight	68 (13.6)	49 (36.0)	56 (14.9)	56 (21.5)	30 (19.2)
Overweight/Obese	49 (9.8)	7 (5.1)	31 (8.2)	24 (9.2)	11 (7.1)
Normal weight	384 (76.6)	80 (58.9)	289 (76.9)	181 (69.3)	115 (73.7)
p	0.018	0.04	0.000	0.019	0.116

N.B. p-value from chi-square test. ANC= Antenatal Care, BMI=Body mass index. All the percentage were in the brackets.

Association between maternal body mass index and LBW.

Results of multivariable logistic regression are presented in table 4 and table 5. Among underweight mothers compared to normal weight, the odds of having LBW babies were respectively 1.29, 1.45, 1.90, 1.50 times higher in Burkina Faso, Malawi, Senegal and Uganda. The odds of having LBW babies were statistically significant among underweight mothers in Senegal only.

As shown in table 5, the nature of the association between maternal BMI and LBW remained nearly the same for all the countries after adjusting for other variables in the models. Compared to normal weight mothers, underweight mothers in all five countries had higher odds of having LBW babies, however the association was statistically significant for Senegal only.

For sensitivity analysis, we performed the regression analysis with different combinations of explanatory variables (not shown), and calculated crude odds ratio. The results did not show any significant deviation from the final analysis.

Table 4. Association (Crude) between maternal BMI and LBW, in selected countries in Africa

	Burkina Faso	Ghana	Malawi	Senegal	Uganda
Birth weight					
Normal	1	1	1	1	1
Underweight	1.298 (0.977-1.724)	1.026 (0.460-2.286)	1.454 (0.948-2.230)	1.909 (1.242-2.933)	1.501 (0.652-3.457)
Overweight	0.870 (0.629-1.203)	0.763 (0.522-1.116)	0.972 (0.593-1.154)	1.048 (0.753-1.457)	1.156 (0.602-1.854)

N.B. Reference category is Normal Birth Weight. Confidence intervals (95%) shown in parenthesis.

Table 5. Association (Adjusted) between maternal BMI and LBW in selected countries in Africa

	Burkina Faso	Ghana	Malawi	Senegal	Uganda
Birth weight					
Normal	1	1	1	1	1
Underweight	1.304 (0.974-1.745)	1.030 (0.453-2.342)	1.449 (0.936-2.242)	1.961 (1,259-3.055)	1.363 (0.587-3.169)
Overweight	0.933 (0.676-1.343)	0.780 (0.533-1.141)	0.998 (0.638-1.265)	1.088 (0.774-1.530)	1.065 (0.526-1.129)

N.B. Regression model adjusted for all the socio-demographic variables which showed significant association p<0.25 in cross-tabs.

Discussion and policy recommendation

Our findings showed considerable variations in the prevalence of BMI and birthweight among the five countries. Percentage of women who were underweight was highest in Senegal and lowest in Ghana, whereas that of overweight was highest in Ghana and lowest in Burkina Faso. Mean birth weight was highest Uganda, and lowest in Burkina Faso. The prevalence of LBW ranged from 10% in Uganda to 15.7% in Senegal. Besides the inter-country differences, the prevalence of LBW varied within countries as well, with the prevalence being higher in rural women compared with urban women. The likelihood of having LBW babies were higher among women with lower parity, attending less than four ANC visits, and reported last pregnancy as unintended. Underweight mothers had a higher likelihood of having LBW babies compared to overweight/obese mothers, however the association was significant for Senegal only.

The rate of LBW for the countries included in this study were found to be similar to regional estimate of 13%, lower than in south Asia 28% and global average for developing countries 16.5%.[25, 26] However, the level is still twice as high compared to developed country average 7%.[26] Countries in Sub-Saharan Africa rank second in terms of the prevalence of LBW after South Asia. As seen at the global level, the rate of progress towards MDGs has been uneven across the countries included in this study. Among the five countries we studied, only Burkina Faso experienced some reduction in the prevalence of LBW during the last decade 18% in 2003 vs 13.4% in 2010-11.[27] For Ghana and Malawi, the situation has worsened considerably since their previous estimates (2% in 2003 Vs 10.2 in 2014) for Ghana, and (5% in 2000 Vs 10 % in 2010).[28, 29]

The rise in the burden of LBW in these countries serves as an indication of a poor/inadequate implementation of national health policies to realise the MDG goals targeted at improving child health outcomes (MDG 4 and 5). This deserves special research attention delving into the underlying causes of the rise in LBW prevalence and call for employing more robust policy agenda to reverse the situation. A commonly proposed strategy to prevent maternal and childbirth-related complications is to take early precaution by providing necessary care for pregnant mothers through antenatal care services. Our results show that the rate of ANC attendance was very low for all the countries. National LBW prevention policies should also focus on strategies to improve ANC visits among mothers, particularly in the rural areas. Besides that, ANC visits have found to be effective in encouraging institutional deliveries which itself reduces the risk of birth-related complications and increases the rate of weighing at birth and thus helps in better monitoring of LBW rates. In Uganda, for instance, the majority of births (about 70%) during the five years preceding the survey were not weighed.[30] This is understandable given that fact that only 37 % of total childbirths have taken place in a health facility.

In line with past findings, our results showed that mothers who were underweight were at higher risk of having low birth weight babies compared with normal weight mothers. Previously, a systematic review including 42 studies found that both in developed and developing countries children born to underweight mother were at higher risk of being low birthweight compared with those born to women with normal weight.[31] This finding was supported by a recent meta-analysis in the context of low-and-middle-income countries: low birthweight was significantly associated with maternal underweight, but not maternal overweight/obesity.[32] These findings warrant for strong policy attention to address under-nutrition among mothers especially because of its intergenerational effects. Though the situation has seen some progress during last 8-10 years, about 5 to 20% women in Africa still suffer from maternal malnutrition due to chronic hunger with adverse consequences on birthweight and infant and maternal mortality.[33] The rate of underweight has declined for Burkina Faso from 20.9% in 2003 in to 11% in 2010-11, Ghana from 9% in 2003 to 4.5% in 2014, Malawi from 9% in 2000 to 5.9% in 2010, Senegal from 21% in 2005 to 16.1% in 2010-11.[27-29] For Uganda however no visible progress has been achieved since 2010 (10.4% in 2000-01 to 10.2% in 2011).[30] As under-nutrition itself is a multifactorial problem, the solution will require developing cross-cutting policies and placing the issue on broad national health and development agenda.

Regarding the impact of overweight/obesity on birthweight outcomes on the other hand, current research evidences are still not sufficiently clear and varies across and within countries. Notably, finding of the present study suggest a protective effect of overweight/obesity on LBW among Ghana and Malawian women. This finding is consistent with an Indian study based on National Family Health Survey NFHS 2, 1998-99.[34] This finding was supported by another conducted in a different Asian setting reporting that the odds of having LBW babies were more than double in underweight women compared to non-obese women.[34] However, these findings conflict with one meta-analysis study which reported that maternal overweight/obesity was associated with lower risk of LBW in developing countries, but the effect did not remain effective after controlling for publication bias.[20] The protective effect of maternal overweight/obesity, however, should not be regarded as a recommendation since it is involved with a range of fetal growth and obstetric complications.[35, 36] Overweight/obese women should, therefore, be given proper counselling regarding the negative impacts of over and underweight so that they can be aware and try controlling their weight before and/or throughout pregnancy period.

Based on nationally representative datasets, the presents study provides valuable insights on the current situation of LBW in selected African countries. To our knowledge, this is the most comprehensive study to focus on the association between maternal body weight status and birthweight outcomes among African women. The surveys were country representative and hence the findings are generalisable for women aged 15-49 years. Findings from this study are expected to assist future researches in this line and the policy makers to devise strategies or intervention programs to address the rising prevalence of LBW. Besides its scientific contributions, few important limitations need to be noted. A major barrier to measuring rates of LBW in developing countries is low prevalence of non-institutional delivery which increases the likelihood of not being weighed at birth. An estimated 75% of new-borns are not weighed sub-Saharan Africa, and therefore data on low birthweight may not be representative of the general population. Another limitation is that as pre-pregnancy BMI was not available, we used the BMI values taken during interview as a proxy and assumed the change as minimal or insignificant which could have impacted the outcome to some degree. However previous studies have adopted post-gestational BMI a predictor of LBW. It is recommended for future studies to focus on pre-gestational BMI and investigate if low BMI is the result of any other illness conditions. Also, the data being cross-sectional study, no causal relationship can be established between the explanatory and response variables.

Conclusion

This study concludes that the rate of low-birthweight remains high and prevalence has been on the rise for some countries during last decade. Women who are underweight had increased odds of having low-birthweight babies, however the odds were statistically significant only for Senegal. In light of the findings it is recommended to take special policy measures to promote universal access to antenatal care attendance among pregnant mothers and provide nutrition counselling at the same time to reduce the burden the underweight. Integrating the provision of supplements/nutritious foods programs during pregnancy could benefit child nutrition and low-birthweight related programs.

Abbreviations

ANC: Antenatal care

DHS: Demographic and health survey

LBW: Low-birthweight

LMICs: Low-and-middle income countries

WHO: World Health Organization

Declarations

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Author contributions: ZFH，GB and YZ conceptualized the study and data collection. ZFH, GB, YS and YZ were responsible for data management and analysis. ZFH and GB contributed to initial drafting and interpretation of the results. DSZ, ZHC was responsible of the linguistic. All authors read the final manuscript and gave approval for publication.

Availability of data and materials: Access to demographic and health survey data is managed and provided by MEASURE DHS following an online registration http://www.dhsprogram.com.

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Ethics approval: The protocol of DHS surveys was approved by the Ethics Committee of ORC Macro Inc. The study was based on analysis of anonymised secondary data available in the public domain of DHS, therefore no additional approval was necessary. However, approval for the reuse of the data was obtained by authors from DHS.

Conflict of interest: Authors have to conflict of interest to declare.

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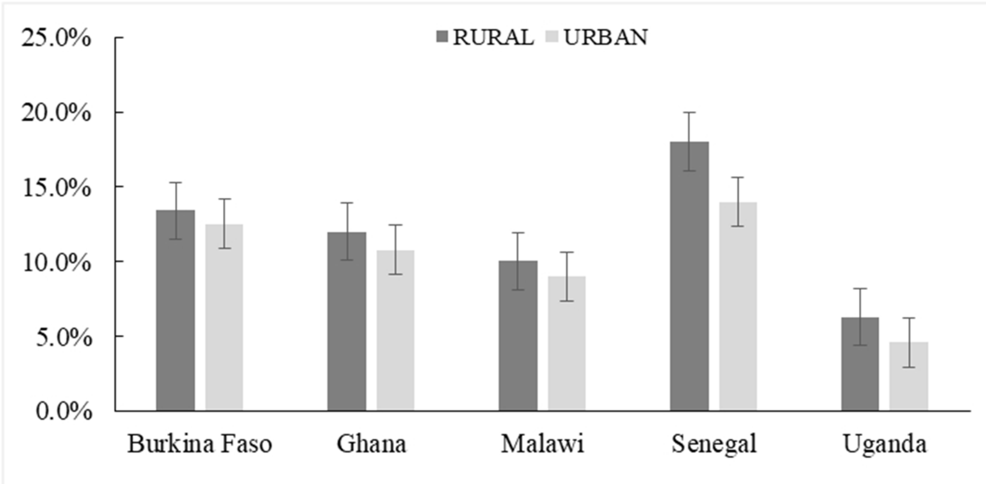
Figure 1: Percentage of LBW babies in individual countries stratified by region

Figure 1 illustrates the percent distribution of LBW babies between urban and rural regions in the individual countries. It shows that prevalence of LBW was higher in rural areas for all countries. Regional difference in LBW prevalence was most noteworthy for Senegal.



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65x32mm (300 x 300 DPI)

STROBE Statement—checklist of items that should be included in reports of observational studies

	Item No	Recommendation
Title and abstract	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract (Page 2)
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found (Page 2)
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported (Page 3)
Objectives	3	State specific objectives, including any prespecified hypotheses (3-4)
Methods		
Study design	4	Present key elements of study design early in the paper (Page 4)
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection (Page 4-5)
Participants	6	*Cross-sectional study*—Give the eligibility criteria, and the sources and methods of selection of participants (Page 5)
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable (Page 6)
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 (Page 6-7)
Bias	9	Describe any efforts to address potential sources of bias (NA)
Study size	10	Explain how the study size was arrived at (Page 6)
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why (Page 7)
Statistical methods	12	(*a*) Describe all statistical methods, including those used to control for confounding (Page 7)
		(*b*) Describe any methods used to examine subgroups and interactions (Page 7)
		(*c*) Explain how missing data were addressed (NA)
		(*e*) Describe any sensitivity analyses (Page 12)

Continued on next page

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 (Page 8)
		(b) Give reasons for non-participation at each stage (NA)
		(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 (Page 8)
		(b) Indicate number of participants with missing data for each variable of interest (Page 8)
Outcome data	15*	
		Case-control study—Report numbers in each exposure category, or summary measures of exposure (Page 8)
		Cross-sectional study—Report numbers of outcome events or summary measures
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 (Page 11-12)
		(*b*) Report category boundaries when continuous variables were categorized (NA)
		(*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 (Page 12)
Discussion		
Key results	18	Summarise key results with reference to study objectives (Page 13)
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 (Page 15-16)
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence (Page 14-15)
Generalisability	21	Discuss the generalisability (external validity) of the study results (Page 15)
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. (Page 17)

*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.