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Obesity

Maternal Body Mass Index and Adverse Pregnancy Outcomes: A Ghanaian Cohort Study

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Objective: To examine the association between maternal weight at <17 weeks gestation and maternal and infant outcomes of pregnancy, delivery, and the postpartum period in pregnant Ghanaian women.
Methods: A prospective cohort study of 1,000 women in Accra, Ghana (2012-2014), was conducted. Women were classified as having overweight (BMI 25-30) and obesity (BMI ≥ 30), and their obstetric and infant outcomes were analyzed using multivariate logistic regression.
Results: The analysis included 824 women, average 28 years (SD 5.1); 313 (31.3%) had overweight and 169 (16.9%) obesity. Women with obesity had a two-fold increased risk for cesarean sections (RR 2.20, 95% CI 1.21-4.02) and more than a six-fold higher risk for pregnancy-induced hypertension (RR 6.17, 95% CI 2.90-13.13) and chronic hypertension (RR 6.00, 95% CI 1.40-25.76). Infants of women with overweight or obesity were more likely to be macrosomic (RR 2.37, 95% CI 1.13-4.97).
Conclusions: The global obesity epidemic has reached women in low- and middle-income countries (LMIC) with important adverse consequences for maternal and infant health. Antenatal care in LMIC will need to anticipate this potential expansion of complications, including the development of guidelines for optimal maternity care for pregnant women with overweight and obesity.

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Introduction

Worldwide, overweight and obesity are an increasing problem. The prevalence of overweight and obesity increased 27.5% over the last three decades: from 28.8% for men and 29.8% for women in 1980 to 36.9% for men and 38.0% for women in 2013. The total number of adults with overweight or obesity has been estimated to be 2.1 billion worldwide (1). Overweight and obesity are risk factors for non-communicable diseases (NCDs) and therefore important targets for health promotion and prevention (2). In many low- and middle-income countries (LMIC), NCDs emerge alongside persisting infectious diseases leading to a double burden of disease. NCDs are estimated to account for 29 million annual deaths in LMIC or 80% of the total NCD mortality burden globally (3,4). Increasing prevalence of NCDs, relative aging due to decreased child mortality, growing urbanization, and related changes in lifestyle such as changes in diet, physical activity, smoking habits, and alcohol use (2,3,5) in part contribute to rising levels of overweight and obesity. In 2013 the prevalence of overweight and obesity among women in West Africa ranged from 12.4% in Chad to 55.7% in Mauritania (1).

The increasing prevalence of obesity in women of reproductive age will affect obstetric outcomes. Studies conducted in high-income countries suggest an association between maternal body mass index (BMI) and complications during pregnancy, delivery, and the postpartum period for both mother and offspring (6,7), including hypertensive disorders in pregnancy (8), gestational diabetes mellitus (GDM) (9), thromboembolic disorders (10), induction of labor (11), cesarean delivery (12), postpartum hemorrhage (PPH) (11), macrosomia (13), congenital abnormalities (14), and maternal, perinatal, and infant deaths (14). Yet results from studies performed in high-income countries may not be directly applicable to the context of LMIC because of the simultaneous burden of both infectious diseases and NCDs and genetic, cultural, and lifestyle differences (3).

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The few studies available on the impact of maternal weight on maternal and neonatal outcomes in LMIC are mainly of cross-sectional nature. Studies from South Africa and Sudan showed overweight and obesity to be associated with increased likelihood of cesarean section, GDM, and macrosomia in pregnant women with obesity (15,16); a study from China showed an association of maternal weight with hypertensive disorders of pregnancy and GDM (17). Therefore, this study examines prospectively the association between maternal weight and adverse maternal and neonatal outcomes of pregnancy, delivery, and the postpartum period in a cohort of pregnant Ghanaian women.

Methods

Study design and study population

In the period from July 2012 to March 2014, 1,010 adult women pregnant <17 weeks were recruited to participate in a prospective cohort study in the Accra Metropolis in Ghana. The Accra Metropolis, which also contains the capital of Ghana, Accra, is one of the local government districts of the Greater Accra region of Ghana. The Greater Accra region contains 16.3% of the population of Ghana and is the most densely populated region in Ghana with an estimated 1,236 persons per square kilometre as compared to the national average of 103 persons per square kilometre. The region as a whole is 90% urban, and the Accra metropolis where this study was conducted is 100% urban. Ghana as a whole is about 50% urban (18). The population growth of Accra at a rate of 3.1% is the highest in the country, but at the same time has the lowest fertility rate in the country. Much of the population growth is due to in-migration from other regions because of the relatively better availability of employment opportunities. It has the lowest poverty levels in the country (19).

Recruitment took place at two hospitals in the Accra Metropolis: the Maamobi General Hospital and the outpatient department of Ridge Regional Hospital. Women <17 weeks pregnant, 18 years or older, and no established hypertension at booking were eligible for inclusion. Included women were interviewed by trained research assistants using a structured questionnaire for socio-demographic (area of birth, area of residence, ethnical groups, religion and marital status), socio-economic characteristics (level of education, economic activity, assets, and household characteristics), and health status including obstetric history. Pregnancy outcomes (maternal and neonatal) were extracted from maternal record books at the two hospitals and through interviews with the participating women. The questionnaires were piloted prior to the start of the study.

Data set, data entry, data validation

Data was entered by trained data clerks using EpiDataEntry (EpiData Association, Odense, Denmark, 2010) and validated by double entry, cleaned and checked for missing data. Missing data were assumed to be missing data at random, and not imputed in the analyses as missing data pertained primarily to outcome data.

Independent variables

BMI (in kg m^{-2}) was calculated by dividing the weight in kilograms by the squared height in meters of the woman at her first antenatal clinic (ANC) visit. Women were categorized into World Health Organization (WHO) BMI categories: underweight (<18.5), normal weight (18.5-24.9), overweight (25-29.9) and obesity (≥30). If categorizing into WHO BMI categories resulted in a number of cases per category of five or less, categories were combined for subsequent statistical analyses.

As a measure of socio-economic status (SES), both maternal level of education and an asset index were used. Level of education was classified in four groups: no education; primary school; junior secondary school (JSS) or vocational training; and senior secondary school (SSS), professional school or higher tertiary education. An asset index was obtained through a principle component analysis of assets and household characteristics and was subsequently classified in low (lowest two quintiles), middle (third and fourth quintile) and high (top quintile) (20).

Dependent variables

Obstetric outcomes. The mode of delivery was classified as vaginal delivery without complications, cesarean section (with distinction between an elective or emergency cesarean section) or an assisted delivery (by vacuum or forceps). PPH was defined as blood loss ≥500 ml within 24 h. The amount of blood loss was visually estimated by the midwife after a vaginal delivery.

New onset hypertension of systolic blood pressure (SBP) ≥ 140 mm Hg or diastolic blood pressure (DBP) ≥ 90 mm Hg after 20 weeks gestation on two separate occasions was classified as pregnancy-induced hypertension (PIH). In case blood pressure was only available from delivery admission, women were classified as PIH if both the SBP and DBP was elevated (21). Women with increased blood pressure before 20 weeks of gestation were retrospectively classified as chronic hypertensives. Pre-eclampsia and eclampsia were analyzed in one combined category of severe hypertensive disorders in pregnancy. Pre-eclampsia was defined as new onset hypertension with proteinuria of 2+ on a dipstick at 20 or more weeks of gestation (21). Women were considered to have eclampsia with the occurrence of tonic-clonic seizures in a pregnant or recently delivered woman (21).

Infant outcomes. Miscarriage was defined as a spontaneous abortion of the foetus before the stage of potential individual survival (22). Stillbirth was defined as the death of the foetus after 24 weeks of gestation (22), and neonatal death as death of a child within the first 28 days of life (23). Birth weight was adjusted for gestational age. Low birth weight was defined as birth weight <2,500 g, macrosomia as birth weight of >4,000 g, independent of gestational age (24).

Apgar score was evaluated at 1 and 5 min, adding scores on five items (heart rate, respiratory effort, muscle tone, reflex irritability, and skin color) together. An Apgar score of ≥7 after 1 or 5 min was considered to be normal (25).

Statistical analysis

Data on categorical variables were presented by frequencies and percentages, and by means and standard deviations (SD) for continuous variables. One-way ANOVA for continuous variables and Pearson's Chi Square test for categorical variables were used to examine demographic characteristics, socio-economic characteristics and pregnancy outcomes by BMI categories. If the number of participants in one or more categories was less than five, Fisher's exact test was applied.

TABLE 1 Pregnancy characteristics of a cohort of women in Accra, Ghana

				BMI category at antenatal booking				
		N	Mean (SD)	<18.5; *N* = 49, mean (SD)	18.5-24.9; *N* = 469, mean (SD)	25-29.9; *N* = 313, mean (SD)	≥30; *N* = 169, mean (SD)	*P* value
Age (in years)		1,000	28.0 (5.14)	26.0 (4.74)	26.7 (4.71)	29.0 (5.32)	30.1 (4.89)	0.00[a]
BMI at ANC booking (kg m^{-2})		1,000	25.4 (4.69)	17.5 (0.73)	22.3 (1.70)	27.2 (1.43)	33.1 (2.73)	0.00[a]
Gestational age at delivery (weeks)		739	39.0 (1.92)	38.7 (3.07)	39.0 (1.88)	39.0 (1.67)	39.2 (2.02)	0.65
			***N* (%)**	***N* (%)**	***N* (%)**	***N* (%)**	***N* (%)**	
Gravida		1,000						0.00[a]
	1		223 (22.3)	18 (36.7)	127 (27.1)	60 (19.2)	18 (10.6)	
	2-3		559 (55.9)	29 (59.2)	269 (57.4)	173 (55.3)	89 (52.4)	
	≥4		218 (21.8)	2 (4.1)	73 (15.6)	80 (25.6)	63 (37.1)	
Gestational age at ANC booking		930						0.64
	First trimester (<13 weeks)		552 (59.4)	30 (65.2)	250 (58.1)	180 (61.2)	92 (57.1)	
	Second trimester (≥13 weeks)		378 (40.6)	16 (34.8)	180 (41.9)	114 (38.8)	69 (42.9)	
Twin pregnancy		824						0.41[b]
	No		818 (99.3)	41 (100)	373 (99.5)	257 (98.5)	147 (100)	
	Yes		6 (0.7)	0 (0.0)	2 (0.5)	4 (1.5)	0 (0.0)	

[a]Significant at *P* value <0.05.
[b]Fisher's exact test with *N* < 5.

To investigate the association between maternal BMI and obstetric and infant outcomes, logistic regression was used for binary dependent variables. Regression analyses were adjusted for confounding factors in different models. In the demographic model, age and number of pregnancies were considered. In the socio-economic model age, number of pregnancies, level of education, and asset index were taken into account. Results were presented as odds ratios (OR) for binary variables with corresponding 95% confidence interval (CI), and interpreted as relative risks (RR). Results were considered to be significant with a *P* value of <0.05. In the logistic regression analyses, underweight and normal weight categories were combined to allow for appropriate numbers of observations per category. BMI was used as a continuous independent variable in the linear regression analyses. All analyses were performed using IBM SPSS Statistics 20 (IBM Corporation, New York City, NY, 2011).

Ethics

Ethical approval was obtained from the Ghana Health Services Ethical Review Committee (GHS-ERC 07-9-11). Participating women provided informed consent prior to study enrollment and were assigned an anonymous participant identification code.

Results

Table 1 includes details on pregnancy characteristics, Table 2 on demographic and socio-economic details. A total of 1,010 women were enrolled in this study, 1,000 women for whom BMI information was available comprised the analytic sample. Outcome information was obtained for 824 women (82.4%). Three maternal deaths of unknown cause occurred during the study period, and 39 pregnancies ended in a miscarriage. The mean age of the women at their first antenatal visit was 28.0 (SD 5.1) years. Mean BMI was 25.4 kg m^{-2} (SD 4.69). Forty-nine women (4.9%) were underweight, 469 (46.9%) had normal weight, 313 (31.3%) were overweight, and 169 (16.9%) had obesity. At ANC booking, most women were in the first trimester (up to 13 weeks) of their pregnancy, with 223 nulliparous (22.3%) and 777 multiparous (77.7%). Mean age ($P < 0.001$) and gravida ($P < 0.001$) were associated with higher BMI categories.

Most women were born (78.5%) and resided (96.8%) in an urban area, and had Akan ethnicity (35.7%). The majority of the women were married (60.0%), and women at higher BMI categories were more likely to be married. Most women had completed junior secondary school education or vocational training (47.3%). The majority was economically active in the informal sector (74.9%).

Obstetric outcomes

Obstetric outcomes are detailed in Table 3. There were six (0.7%) twin pregnancies. The mean gestational age at delivery was 39 weeks (SD 1.92). Ninety women (8.9%) delivered their child by cesarean section, of which 49 (54.4%) had emergency cesarean sections. The number of cesarean sections varied significantly between BMI categories ($P = 0.01$), with higher incidence of cesarean deliveries in women with higher BMI (range 2.5% in women with underweight to 17.8% in women with obesity). The amount of blood loss

TABLE 2 Demographic and socio-economic characteristics of a cohort of pregnant women in Accra, Ghana

				BMI category at antenatal booking				
		N = 1,000	*N* (%)	<18.5; *N* = 49, *N* (%)	18.5-24.9; *N* = 469, *N* (%)	25-29.9; *N* = 313, *N* (%)	≥30; *N* = 169, *N* (%)	*P* value
Area of birth								0.07[b]
	Ghana urban area		785 (78.5)	40 (81.6)	356 (75.9)	258 (82.4)	132 (77.6)	
	Ghana rural area		196 (19.6)	6 (12.2)	102 (21.7)	52 (16.6)	36 (21.2)	
	West African country		19 (1.9)	3 (6.1)	11 (2.3)	3 (1.0)	2 (1.2)	
Area of residence								0.87[b]
	Accra metropolitan area		780 (78.0)	40 (81.6)	368(78.5)	246 (78.6)	127 (74.7)	
	Other urban area		188 (18.8)	7 (14.3)	87 (18.6)	58 (18.5)	36 (21.2)	
	Peri-urban and rural area		32 (3.2)	2 (4.1)	14 (3.0)	9 (2.9)	7 (4.1)	
Ethnical groups								0.55
	Akan		357 (35.7)	18 (36.7)	176 (37.5)	102 (32.6)	61 (35.9)	
	Hausa		195 (19.5)	10 (20.4)	78 (16.6)	74 (23.6)	33 (19.4)	
	Ewe		210 (21.0)	9 (18.4)	100 (21.3)	69 (22.0)	33 (19.4)	
	Ga, Ga-Dangme		94 (9.4)	5 (10.2)	42 (9.0)	25 (8.0)	22 (12.9)	
	Other		144 (14.4)	7 (14.3)	73 (15.6)	43 (13.7)	21 (12.4)	
Religion								0.50
	Christianity		715 (71.5)	35 (71.4)	344 (73.3)	214 (68.4)	123 (72.4)	
	Islam		285 (28.5)	14 (28.6)	125 (26.7)	99 (31.6)	47 (27.6)	
Marital status								0.00[a]
	Single, widowed		189 (18.9)	10 (20.4)	99 (21.1)	58 (18.5)	23 (13.5)	
	Married		600 (60.0)	34 (69.4)	247 (52.7)	200 (63.9)	119 (70.0)	
	Engaged, living together		211 (21.1)	5 (10.2)	123 (26.2)	55 (17.6)	28 (16.5)	
Level of education								0.12
	No education		111 (11.1)	5 (10.2)	63(13.4)	33 (10.5)	10 (5.9)	
	Primary school		130 (13.0)	5 (10.2)	60 (12.8)	50 (16.0)	15 (8.8)	
	Lower secondary school (JSS) and vocational training		473 (47.3)	24 (49.0)	217 (46.3)	141 (45.0)	91 (53.5)	
	Upper secondary school (SSS), professional school, and higher tertiary education		286 (28.6)	15 (30.6)	129 (27.5)	89 (28.4)	54 (31.8)	
Economic activity								0.81
	Informal sector employment		748 (74.9)	33 (67.3)	351 (74.8)	233 (74.4)	131 (77.1)	
	Formally employed		120 (12.0)	7 (14.3)	53 (11.3)	39 (12.5)	21 (12.4)	
	Not economically active		132 (13.2)	9 (18.4)	65 (13.9)	41 (13.1)	18 (10.6)	
Asset index								0.27
	Lowest 40%		401 (40.1)	20 (40.8)	206 (43.9)	118 (37.7)	58 (34.1)	
	Middle 40%		400 (40.0)	20 (40.8)	181 (38.6)	124 (39.6)	75 (44.1)	
	Highest 20%		199 (19.9)	9 (18.4)	82 (17.5)	71 (22.7)	37 (21.8)	

[a]Significant at *P* value <0.05.
[b]Fisher's exact test with *N* < 5.

[in millilitres (ml)] increased significantly with higher BMI categories, ranging from 139 ml (SD 68) in the lowest category to 220 (SD 118) in the highest. PPH occurred in 28 cases (3.8%), with a trend towards an increase with higher BMI. PIH occurred more frequently in higher BMI categories, with the highest incidence of 17.9% in women with obesity, compared to 4.5% in women with normal weight. The same significant trend was observed in women with chronic hypertension: 7.3% of the women in the highest BMI category had an increased blood pressure. No difference was observed for severe hypertensive disorders.

Infant outcomes

Infant outcomes are given in Table 4. Incidence of miscarriage did not differ in maternal BMI groups. The occurrence of stillbirth or neonatal death was the highest in the underweight BMI

TABLE 3 Overview of obstetric outcomes of a cohort of pregnant women in Accra, Ghana

				BMI category at antenatal booking				
		N	Mean (SD)	<18.5; *N* = 49, mean (SD)	18.5-24.9; *N* = 469, mean (SD)	25-29.9; *N* = 313, mean (SD)	≥30; *N* = 169, mean (SD)	*P* value
Estimated blood loss (ml)		705	187 (112)	139 (68)	173 (91)	195 (134)	220 (118)	0.00[a]
			***N* (%)**	***N* (%)**	***N* (%)**	***N* (%)**	***N* (%)**	
Maternal death		792						0.36[b]
	No		789 (99.6)	40 (100)	361 (100)	248 (99.2)	135 (99.3)	
	Yes		3 (0.4)	0 (0.0)	0 (0.0)	2 (0.8)	1 (0.7)	
Type of delivery		790						0.01[a,b]
	Vaginal delivery		700 (88.6)	39 (97.5)	329 (91.1)	218 (87.6)	111 (82.2)	
	Cesarean section		90 (8.9)	1 (2.5)	32 (8.9)	31(12.4)	24 (17.8)	
Indication of cesarean section		66						0.13[b]
	Elective		17 (25.8)	1 (100)	7 (29.2)	3 (13.6)	6 (35.3)	
	Emergency		49 (74.2)	0 (0.0)	17 (70.8)	19 (86.4)	11 (64.7)	
Postpartum heamorrhage		740						0.45[b]
	No		712 (96.2)	38 (97.4)	322 (97.3)	227 (95.0)	121 (95.3)	
	Yes		28 (3.8)	1 (2.6)	9 (2.7)	12 (5.0)	6 (4.7)	
Pregnancy-induced hypertension		759						0.00[a,b]
	No		700 (92.2)	40 (100)	338 (95.5)	219 (62.0)	101 (82.1)	
	Yes		59 (7.8)	0 (0.0)	16 (4.5)	19 (8.0)	22 (17.9)	
Chronic hypertension		716						0.00[a,b]
	No		700 (97.8)	40 (100)	338 (99.1)	219 (97.8)	101 (92.7)	
	Yes		16 (2.2)	0 (0.0)	3 (0.9)	5 (2.2)	8 (7.3)	
Severe hypertensive disorders		779						0.21[a,b]
	No		765 (98.2)	39 (100)	351 (99.2)	242 (97.6)	129 (97.0)	
	Yes		14 (1.8)	0 (0.0)	3 (0.8)	6 (2.4)	4 (3.0)	

[a]Significant at *P* value <0.05.
[b]Fisher's exact test with *N* < 5.

category ($n = 3$, 7.5%). Mean birth weight was 3,119 g (SD 498), and increased with higher maternal BMI [range 2,915 g (SD 554) to 3,228 g (SD 521)] also after adjustment for gestational age. Low birth weight occurred in 58 cases (7.4%), with the highest incidence in mothers being underweight (12.5%, $P = 0.52$), whereas macrosomic babies were mainly born to mothers with increased BMI (range 2.5-6.8%, $P = 0.06$). No differences in Apgar scores below 7 at 1 and 5 min were observed between BMI categories.

Association between BMI and obstetric outcomes

Table 5 includes details on the association between BMI and obstetric outcomes. Women with overweight had a two-fold increased risk for developing PIH (RR 2.41, 95% CI 1.15 to 5.05) and a trend towards an increased risk of cesarean sections (RR 1.46, 95% CI 0.85 to 2.49). Women with obesity had a two-fold increased risk for cesarean sections (RR 2.20, 95% CI 1.21 to 4.02), and more than a six-fold higher risk to develop PIH (RR 6.17, 95% CI 2.90 to 13.13) and chronic hypertension (RR 6.00, 95% CI 1.40 to 25.76). A trend towards increased risk of emergency cesarean section, PPH and severe hypertensive disorders could be observed for both women with overweight and obesity.

Association between BMI and infant outcomes

Women with overweight had a two-fold higher risk of having a marcosomic child (RR 2.37, 95% CI 1.13 to 4.97, $P = 0.02$), for women with obesity a similar trend (RR 1.84, 95% CI 0.74-4.58, $P = 0.19$) was observed. No association was seen between overweight or obesity and risk of miscarriage, stillbirth, neonatal death, low Apgar scores at 1 and 5 min or low birth weight.

Discussion

We observed an increased risk of cesarean sections, PIH, chronic hypertension and macrosomia for women with overweight or obesity.

In our cohort of 1,000 women, the percentage of women with overweight and obesity was 31.3 and 16.9%, respectively. The prevalence of overweight and obesity in our population is higher than the

TABLE 4 Overview of infant outcomes of a cohort of pregnant women in Accra, Ghana

				BMI category at antenatal booking				
		N	Mean (SD)	<18.5; *N* = 49, mean (SD)	18.5-24.9; *N* = 469, mean (SD)	25-29.9; *N* = 313, mean (SD)	≥30; *N* = 169, mean (SD)	*P* value
Birth weight (g)		782	3119 (498)	2915 (554)	3083 (462)	3145 (515)	3228 (521)	0.00[a]
Birth weight for gestational age		731	0.0 (1.0)	−0.38 (0.96)	−0.10 (0.94)	0.09 (1.02)	0.24 (1.07)	0.00[a]
			***N* (%)**	***N* (%)**	***N* (%)**	***N* (%)**	***N* (%)**	
Miscarriage		825						0.28[b]
	No		786 (95.3)	39 (95.1)	361 (96.3)	247 (95.7)	134 (92.4)	
	Yes		39 (4.7)	2 (4.9)	14 (3.7)	11 (4.3)	11 (7.6)	
Stillbirth or neonatal death		796						0.05[a,b]
	No		784 (98.5)	37 (92.5)	359 (98.9)	249 (98.4)	134 (99.3)	
	Yes		12 (1.5)	3 (7.5)	4 (1.1)	4 (1.6)	1 (0.7)	
Low birth weight		780						0.52
	No		722 (92.6)	35 (87.5)	327 (92.1)	232 (93.9)	123 (92.5)	
	Yes		58 (7.4)	5 (12.5)	28 (7.9)	15 (6.1)	10 (7.5)	
Macrosomia		782						0.06[b]
	No		740 (94.6)	39 (97.5)	344 (96.6)	228 (91.9)	124 (93.2)	
	Yes		42 (5.4)	1 (2.5)	12 (4.3)	20 (8.1)	9 (6.8)	
Apgar score ≥7 after 1 minute		762						0.45
	No		117 (15.4)	8 (20.5)	46 (13.3)	42 (17.3)	19 (14.6)	
	Yes		645 (84.6)	31 (79.5)	299 (86.7)	201 (82.7)	111 (85.4)	
Apgar score ≥7 after 5 minutes		760						0.28[b]
	No		31 (4.1)	4 (10.3)	13 (3.8)	9 (3.7)	5 (3.9)	
	Yes		729 (95.9)	35(89.7)	332 (96.2)	233(96.3)	124 (96.1)	

[a]Significant at *P* value <0.05.
[b]Fisher's exact test with *N* < 5.

global average in developed or developing countries (1). Yet, they are in line with the previously reported prevalence of overweight in the Women's Health Study of Accra, Wave II (WHSA-II), which reported 27.8% of the adult Ghanaian women being overweight (26). However, prevalence of obesity in our study was considerably lower than obesity reported by WHSA (37.1%), most likely due to an on average older WHSA-II study population (27).

Our findings align to observations from high-income country settings. In a meta-analysis by Poobalan et al. the risk of a cesarean section (CS) is increased for women with overweight (OR 1.53, 95% CI 1.48 to 1.58, emergency CS OR 1.64, 95% CI 1.55 to 1.73) and women with obesity (OR 2.36, 95% CI 2.15 to 2.59, emergency CS OR 2.23, 95% CI 2.07 to 2.42) (12). We did not observe a similar increase in emergency CSs, possibly due to a lack of power. Increased risk of cesarean delivery in women with overweight or obesity can be related to a decreased rate of cervical dilation, increased rate of induction of labor (not included in this study), presence of comorbid conditions such as diabetes mellitus or hypertension, and macrosomia of the baby, which are all risk factors for having a (emergency) cesarean section (28). This higher incidence of (emergency) cesarean deliveries in women with an increased BMI is of concern, especially because complications including anesthesia problems, deep venous thrombosis, wound infection, separation and hemorrhage of the wound, and lower chance of having a successful vaginal delivery with a next pregnancy, are more frequent (28).

A study performed in the United Kingdom (UK) assessed the association between overweight and obesity with PPH and analyzed 20,604 vaginal deliveries with 1,510 cases of PPH. An elevated risk of having PPH for women with overweight (RR 1.2, 99% CI 1.0 to 1.4) or obesity (RR 1.3, 99% CI 1.0 to 1.7) was observed (11). In the current study a trend towards an increased rate was observed, possibly a reflection of the lower power of the study compared to the study by Scott-Pillai et al. (11).

Relative risk of PIH was significantly increased for women with overweight or obesity, adding to previous studies performed in the Netherlands and the UK, showing ORs for PIH varying between 1.76 (95% CI 1.60 to 1.95) for women with overweight and 6.31 (95% CI 4.30 to 9.26) for women with obesity (29,30). The observed increased risk to develop PIH is of relevance, because in 15 to 25% of women with PIH, PIH progresses to pre-eclampsia (31). We observed a trend towards an increased relative risk of severe hypertensive disorders of pregnancy for women in the combined overweight and obesity category. In the pathogenesis of pre-eclampsia, systemic hyperinflammation plays an important role and eventually results in onset of clinical disease (21). Adipose tissue of women with obesity generates more actively several inflammatory

TABLE 5 Association of BMI category at antenatal booking and subsequent obstetric and infant outcomes for pregnant women from Accra, Ghana

	BMI category at antenatal booking									
	Demographic model					Socio-economic model				
	<25	25-29.9		≥30		<25	25-29.9		≥30	
	RR (95% CI)	RR (95% CI)	*P* value	RR (95% CI)	*P* value	RR (95% CI)	RR (95% CI)	*P* value	RR (95% CI)	*P* value
Obstetrical outcomes										
Cesarean section	Ref.	1.38 (0.81-2.36)	0.24	2.11 (1.17-3.81)	0.01[a]	Ref.	1.46 (0.85-2.49)	0.17	2.20 (1.21-4.02)	0.01[a]
Emergency cesarean section	Ref.	3.87 (0.81-18.44)	0.09	1.22 (0.29-5.14)	0.79	Ref.	3.80 (0.71-20.41)	0.12	1.16 (0.26-5.19)	0.85
PPH	Ref.	1.85 (0.77-4.43)	0.17	1.78 (0.61-5.17)	0.29	Ref.	1.89 (0.78-4.55)	0.16	1.78 (0.61-5.21)	0.30
PIH	Ref.	2.16 (1.08-4.34)	0.03[a]	5.71 (2.81-11.63)	0.00[a]	Ref.	2.41 (1.15-5.05)	0.02[a]	6.17 (2.90-13.13)	0.00[a]
Chronic hypertension	Ref.	1.93 (0.44-8.45)	0.38	6.14 (1.53-24.64)	0.01[a]	Ref.	1.99 (0.43-9.14)	0.38	6.00 (1.40-25.76)	0.02[a]
Neonatal outcomes										
Miscarriage	Ref.	0.94 (0.42-2.09)	0.87	1.64 (0.72-3.77)	0.24	Ref.	0.98 (0.44-2.22)	0.97	1.59 (0.68-3.69)	0.28
Low birth weight	Ref.	0.77 (0.41-1.47)	0.43	1.04 (0.48-2.23)	0.93	Ref.	0.77 (0.41-1.47)	0.43	1.06 (0.49-2.29)	0.89
Macrosomia	Ref.	2.40 (1.16-4.99)	0.02[a]	1.93 (0.78-4.76)	0.16	Ref.	2.37 (1.13-4.97)	0.02[a]	1.84 (0.74-4.58)	0.19
Apgar score at 1 min	Ref.	1.21 (0.77-1.90)	0.40	0.97 (0.54-1.73)	0.90	Ref.	1.23 (0.78-1.93)	0.38	0.98 (0.54-1.77)	0.95

Demographic model: adjusted for age and number of pregnancies.
Socio-economic model: adjusted for age, number of pregnancies, level of education, and asset index.
[a]Significant at P value <0.05.

mediators (C-reactive protein, interleukin-6) resulting in excessive inflammatory response (32). This state of hyperinflammation could result in an increased risk of pre-eclampsia in women with overweight and obesity (32).

The risk of miscarriage, stillbirth and neonatal death was not significantly related to BMI and tended to decrease with an increasing BMI. This is in contrast with findings of other studies performed in high-income countries, showing an increased risk of these outcomes in pregnancies of women with a higher BMI (33). Possible explanation for this could be that women with a miscarriage, especially when this occurred in early pregnancy, may not have presented at the routine ANC where inclusion took place. The incidence of miscarriage in our study was low (4.7%)—compared to the Greater Accra Region in the Ghana Maternal Health Survey of 2007 (11.1%), whereas the incidence of stillbirth or neonatal death was comparable (1.4% in this study compared to 1.2% in the survey).

We did not observe adverse infant outcomes of overweight or obesity other than macrosomia. This is in line with a meta-analysis by Yu et al., in which overweight or obesity was observed to be associated with birth weight of >4,000 g (OR 1.53, 95% CI 1.44 to 1.63 for women with overweight; and OR 2.00, 95% CI 1.84 to 2.18 for women with obesity) (34). Overweight and obesity are risk factors for development of insulin resistance during pregnancy, causing GDM and possible macrosomia of the infant (9). As routine blood glucose level screening of GDM has not yet been implemented in the participating hospitals, similar to the current practice in many other LMIC, information on incidence of GDM was not available for this cohort (35). Therefore, the distinction between the effect of overweight and the combined effect of overweight and GDM on macrosomia could not be made.

A strength of this study is the prospective data collection early in pregnancy of a large urban cohort of 1,000 women, and one of the first performed in a lower middle-income country. Extensive effort was made to complete the study, reflected by the relatively high follow-up (>80%). Women who were lost to follow-up were slightly younger, more likely to be nulliparous and had a lower BMI at booking. The majority of them had a normal weight (53.4%). They were also more likely to have a lower socio-economic status (lower education, more often among the poorest 40% of the population, more often single or engaged, or born in rural areas), therefore a possible reason for the loss to follow-up is that these women may have travelled to their home towns for assistance during and after delivery.

Limitations of the current study relate to the use of maternal BMI based on weight during early pregnancy, as a proxy for pre-pregnancy weight, which may be influenced by weight gain in pregnancy (36,37). This could possibly influence the interpretation of the results, and should be considered for future studies. Likewise, the absolute gestational weight gained during pregnancy has been associated with an increased risk of adverse pregnancy outcomes and would be of interest to be considered in future studies as well (29,30). Although smoking is most probably not an important confounding factor in this Ghanaian study population given the low prevalence of smoking among women (0.3%) (38), future studies could, depending on cultural context and common practice, include data collection on smoking habits.

Conclusion

The global obesity epidemic has reached women in LMIC with important adverse consequences for maternal and infant health. Antenatal care in LMIC will need to anticipate this potential expansion of complications, including the development of guidelines for optimal maternity care for pregnant women with overweight and obesity. O

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