TITLE: Maternal obesity and caesarean delivery in Sub-Saharan Africa

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ABSTRACT:

Objectives: Obesity has been identified as a risk factor for caesarean delivery in high-income settings, and is an emerging public health issue in low-income settings. The objective of this paper is to quantify maternal obesity as a risk factor for caesarean delivery in Sub-Saharan Africa.

Methods: Multivariable logistic regression analysis using thirty-one nationally-representative cross-sectional data sets from the Demographic and Health Surveys (DHS).

Results: Maternal obesity was a risk factor for caesarean delivery in Sub-Saharan Africa; a clear dose-response relationship (where the magnitude of the association increased with increasing BMI) was observable. Compared to women of optimal weight, overweight women (BMI 25-29 kg/m^2) were significantly more likely to deliver by caesarean (OR: 1.54; 95% CI: 1.33, 1.78), as were obese women (30-34.9kg/m^2 (OR: 2.39; 95%CI: 1.96-2.90); 35-39.9kg/m^2 (OR: 2.47 95%CI: 1.78-3.43)) and morbidly obese women (BMI ≥40 kg/m^2 OR: 3.85; 95% CI: 2.46-6.00).

Conclusions: BMI is projected to rise substantially in Sub-Saharan Africa over the next few decades and demand for caesarean sections already exceeds available capacity. Overweight women should be advised to lose weight prior to pregnancy. Furthermore, culturally appropriate prevention strategies to discourage further population-level rises in BMI need to be designed and implemented.

Keywords: body mass index, overweight, obesity, caesarean delivery, Sub-Saharan Africa

BACKGROUND:

Obesity is an emerging public health issue in low-income settings, including Sub-Saharan Africa. Rising levels of obesity have been associated with increasing national income; age-standardised mean BMI has been shown to increase most rapidly until an income of about I$5,000 (international dollars), peaking at about I$12,500 for females and I$17,000 for males (1). In Sub-Saharan Africa, gross national income currently ranges from around I$350 (Democratic Republic of Congo) to I$24,110 (Equatorial Guinea), with a regional mean of I$2,251 (2). Substantial rises in BMI may therefore be expected as the region develops economically and undergoes the nutrition transition (3-5). Increased BMI is a risk factor for adverse health outcomes, including those related to neonatal mortality and reproductive health (6, 7).

The association between maternal obesity and caesarean delivery is well established in high-income settings (8, 9). Obesity may act through several mechanisms.. Increased maternal body fat could reduce the effectiveness of uterine contractions during labour (10, 11). Furthermore, infants born to overweight and obese mothers are at increased risk of macrosomia (birth weight greater than 4000g), which increases the risk of cephalopelvic disproportion and obstructed labour (12, 13). Maternal obesity is associated with adverse maternal outcomes including increased hypertension and pre-eclampsia and gestational diabetes (14, 15), and to adverse foetal outcomes such as congenital abnormalities, and foetal and neonatal death (6, 16, 17). All these are likely to lead to a higher need for caesarean section.

The context of the majority of caesarean deliveries in Sub-Saharan Africa is very different to that typically observed in high-income settings: Sub-Saharan Africa is a region with a substantial unmet need for caesarean delivery care (18, 19). Caesarean rates are strongly associated with both

urban/rural and socio-economic status; with a much larger differential observed than that reported for either antenatal or skilled delivery care (20). A systematic review of studies involving caesarean sections in Sub-Saharan Africa between 1970-2000 found that about 75% of caesareans were carried out for severe maternal indications, namely prolonged labour, previous caesarean section, malpresentation, placental abruption, placenta praevia or eclampsia (18). Conversely, amongst a small group of the most affluent women, childbirth may be over-medicalised, and unnecessary caesareans, which also carry an excess risk of adverse outcomes, occur.

Although some studies have looked at the relationship between maternal obesity and caesarean delivery in Sub-Saharan Africa, these have generally not adjusted for confounders, particularly wealth, (21-24) or been sufficiently powered to present results for different levels of obesity. A hospital-based study from Khartoum, Sudan demonstrated a strong relationship between increased BMI and caesarean delivery (25). A retrospective study of 752 deliveries in Johannesburg, South Africa found that a slightly higher proportion of morbidly obese women (BMI >40 kg/m^2) delivered by caesarean section (55.3% vs. 48.3%) or required an assisted delivery (5.3% vs. 1.4%) compared to optimal weight women, but this difference was not statistically significant (p=0.15) (26).

The aim of this paper is to quantify the association between maternal BMI and caesarean delivery in Sub-Saharan Africa using population-based survey data.

METHODS:

The Demographic and Health Surveys (DHS) are nationally-representative cross-sectional household surveys that use a standardised core questionnaire to facilitate cross-country comparisons. To generate a large dataset with sufficient statistical power to investigate the association between

maternal BMI and mode of delivery, data from thirty-one countries in Sub-Saharan Africa where at least one DHS had been conducted since 2000 were pooled (**TABLE 1**). The most recent survey was used in countries where more than one survey had been conducted. The mode of delivery for the most recent birth for each woman within the five years preceding the survey was considered, assessed by the woman's response to the question "Was NAME delivered by caesarean, that is did they cut your belly open to take the baby out?". Multiple births (twins, triplets etc.) were excluded.

Weight and height were measured by interviewers during the survey using a standardised protocol across countries (27). Body Mass Index (BMI) was calculated as weight (in kilograms) divided by height (in metres) squared. Standard WHO classifications were used: underweight (<18·5 kg/m^2), optimal weight (18·5-24·9 kg/m^2), overweight (25-29·9 kg/m^2) and obese, divided into class I (30-34·9 kg/m^2), class II (35-39·9 kg/m^2) and class III (≥40 kg/m^2). We excluded women who were pregnant or less than three months postpartum at the time of data collection because their BMI values might have been inflated because of weight gain due to pregnancy. Women younger than twenty years were excluded because they might not have attained adult stature.

Confounders included in the model were maternal age (5-year age groups), previous caesarean delivery within the preceding five years (yes/no), urban/rural residence, relative asset index (wealth) quintile, maternal education (highest level of schooling attended) and birth order of the index birth. As BMI was assessed at interview and not pre-pregnancy, a variable was added to control for the months elapsed between the index birth and the survey. Country was included as a fixed effect in all models.

After preliminary exploration of the data, multivariable logistic regression was used to investigate the association between maternal BMI category and mode of delivery (vaginal vs. caesarean), adjusted for the above confounding factors, specified *a priori*. The linear effect of BMI was also examined for evidence of a dose-response relationship.

Stata/SE 13.0 was used for all analyses. Features of complex survey design (sampling weights, clustering and stratification) were taken into account using The Stata -*svy*- suite of commands with the -*subpop()*- option.

RESULTS:

153,102 women were included in this analysis (**TABLE 1**). The smallest sample was from Chad with 2,286 women and the largest from Nigeria with 14,674 women. Twenty percent of all women were overweight or obese (14.6% had a BMI between 25-29.9 kg/m^2, 3.9% had a BMI between 30-34.9 kg/m^2, 1.0% had a BMI between 35-39.9kg/m^2 and 0.4% had a BMI greater than 40 kg/m^2), 68% had an optimal BMI and 12% were underweight. There was substantial national variation in the proportion of overweight or obese, which ranged from 5% in Ethiopia to 56% in Swaziland. Overall, 4.4% of women in the sample delivered by caesarean section at the index birth, ranging from 0.5% (Chad) to 15.6% (Namibia).

A dose-response relationship was clearly observable in the proportion of women delivery by caesarean section by maternal BMI (**FIGURE 1**). In the unadjusted analysis (**TABLE 2**), the odds of caesarean delivery at the index birth increased with increasing maternal BMI; the odds of morbidly

obese women with a BMI ≥40 kg/m^2 delivering by caesarean were more than seven times greater compared to women of optimal weight (OR: 7.31; 95% CI: 4.77, 11.21).

The adjusted results from the multivariable model are presented in **TABLE 2**. After adjusting for maternal age, previous caesarean delivery, relative wealth quintile, urban/rural residence, parity, maternal education and the months elapsed since the index birth, women had more than twice the odds of delivering by caesarean section if they were obese compared to women of optimal weight. Women who were morbidly obese had more than three times the odds of caesarean delivery compared to those of optimal weight (OR: 3.85; 95% CI: 2.46, 6.00).

In Sub-Saharan Africa, urban/rural residence, relative wealth quintile and maternal education are strong indicators of access to caesarean delivery due to substantial unmet need for caesareans, thus there is a risk of over-adjustment. We conducted a sensitivity analysis of the relationship between maternal BMI and caesarean delivery adjusting for previous caesarean, maternal age group, parity and time elapsed only. The pattern of the association did not change, although the magnitude of the effect size increased somewhat (underweight aOR: 0.68; 95% CI: 0.55-0.84; overweight aOR: 2.01; 95% CI: 1.73-2.32; obese class I aOR: 3.50; 95% CI: 2.89-4.24; obese class II aOR: 3.76; 95% CI: 2.71-5.22; obese class III aOR: 5.90; 95% CI: 3.82-9.11).

DISCUSSION:

Overweight women comprised 15% percent of this representative sample of women from thirty-one countries in Sub-Saharan Africa who had delivered within the previous five years, and a further 5% were obese. Overall 4% of women delivered by caesarean section at their most recent delivery.

Maternal obesity significantly increased the odds of caesarean delivery, compared to women of optimal weight; a clear dose-response relationship was observed with more women delivering by caesarean the higher maternal BMI. An important observation was that even in the overweight category (25-29.9 kg/m^2) - BMI values which would be considered relatively unremarkable in many high-income countries - women were significantly more likely to deliver by caesarean than those of optimal weight after adjustment for socio-demographic confounders.

The key strengths of this study are the availability of a large, nationally-representative dataset, allowing the effect of maternal BMI on mode of delivery to be estimated using population-based data. Standardised questionnaires and height/weight measurement protocols were used across countries and time, which facilitated international comparisons. The few previous studies that examine the association between maternal obesity and caesarean delivery in Sub-Saharan Africa have used facility-based data, which is subject to selection bias in a setting where large numbers of women deliver at home. Furthermore, this study was able to adjust for multiple confounding variables, which has been a common limitation of previous work.

Our findings are comparable to those observed in high-income settings. Two global systematic reviews (8, 9) have found pooled effect estimates very similar to those found in our study (**TABLE 3**). A systematic review focusing on maternal obesity in Africa found that obese mothers were 87% more likely to deliver by caesarean than those who were not obese (7). The fact that the association is robust to different populations suggests that the underlying mechanism between increased risk of caesarean delivery and maternal obesity may be largely biological. A number of mechanisms have been proposed. There is evidence that obese mothers have less effective uterine contractility(10); furthermore maternal obesity is a risk factor for macrosomia which may increase the risk of cephalopelvic disproportion and the need for caesarean section (28). Maternal obesity is also a risk

factor for other complications including hypertension and gestational diabetes, which are also managed with caesarean delivery (14, 15).

However, our results should be interpreted in light of a number of methodological limitations, several of which stem from the cross-sectional design of the DHS. Pre-pregnancy BMI was unavailable; therefore, we assumed that maternal BMI category at the time of the survey was the same as prior to the most recent (index) birth. We excluded women who were deemed likely to have experienced substantial changes in body size from the analysis, namely those who were pregnant or less than three months postpartum at the time of data collection and those women younger than 20 years at the time of the survey who may not have attained adult stature. . Mean time elapsed between the index birth and the time of data collection was 23 months, and the maximum time elapsed was 60 months; time elapsed was controlled for in the multivariable model (aOR: 1.00; 95% CI: 1.00-1.01). We used the standard WHO BMI categories to define overweight and obesity in this study: these categories are intended and recommended for international use (29) although it is acknowledged that there may be differences in equivalent risk across ethnic groups depending on the outcome (30).

Mode of delivery was based on maternal recall. In previous rounds of the DHS, reported caesarean rates have been found to be generally higher than estimates of rates obtained from health facilities, although mostly still lay within the respective 95% confidence intervals (31). Subsequent changes to the questionnaire design, such as a skip pattern that restricts the caesarean question to those women who delivered in a health facility, should have further improved the data (32). Recall bias is unlikely to represent a substantial concern to these results because only the most recent birth of occurring in the five years preceding data collection were considered in the analysis.

Common to all secondary data analyses, we were restricted in our analyses by the availability of variables. Specifically, it would have been interesting to investigate potential effect modification depending on whether a caesarean was an elective or emergency operation, data that are not available in the DHS. Caesarean rates are rising in Sub-Saharan Africa but remain low overall, lack of access to emergency obstetric care remains a concern in the region (19).

Increases in population average BMI has been associated with economic development (1). Indeed, it has been projected that by 2030 there will be 113.1 million obese adults living in Sub-Saharan Africa, a prevalence of 17.5% (33). Sub-Saharan Africa is faced with a double burden of obesity-related health problems, currently the subject of heavy focus in high-income settings, whilst still dealing with unresolved issues of infectious diseases and malnutrition, and weak and under-funded health infrastructure. There is already considerable unmet need for caesarean sections at the national level in Sub-Saharan Africa; rising levels of maternal obesity are likely to increase need for caesarean sections and thus further stretch capacity in the future.

A key policy recommendation arising from this study is that overweight and obese women of reproductive age in Sub-Saharan Africa should be advised to lose weight prior to pregnancy and post pregnancy (34). Physical activity during pregnancy is also recommended in the recent FIGO guidelines (35). However, experience from high-income settings has shown that public health interventions designed to help individuals maintain an optimal body weight are challenging to implement. Population-level prevention policies that are culturally appropriate to the Sub-Saharan setting need to be designed and implemented. There cannot be a single solution, although work is ongoing in developing appropriate theoretical frameworks (36). Currently little information exists on the

knowledge and perceptions of healthcare providers towards maternal obesity in Africa, or on stakeholder's views of appropriate interventions, as highlighted in a recent systematic review (7). Few African countries have specific guidelines on the management of obese pregnant women (37), South Africa being one exception (38). As maternal obesity seems likely to increase in the future this is an important area that deserves further attention (35).

This paper has quantified the association between maternal BMI and caesarean delivery in Sub-Saharan Africa using population-representative data. After adjustment for confounding factors including maternal age and relative wealth, women who were morbidly obese (BMI ≥ 40kg/m^2) had over three times the odds of delivering by caesarean section than those of optimal weight. BMI is projected to rise substantially in Sub-Saharan Africa over the next few decades and demand for caesarean sections already exceeds available capacity. Furthermore, culturally appropriate prevention strategies to discourage further population-level rises in BMI need to be designed and implemented.

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FIGURE 1: Proportion of deliveries by caesarean section by maternal BMI. Grey bars represent 95% confidence intervals.

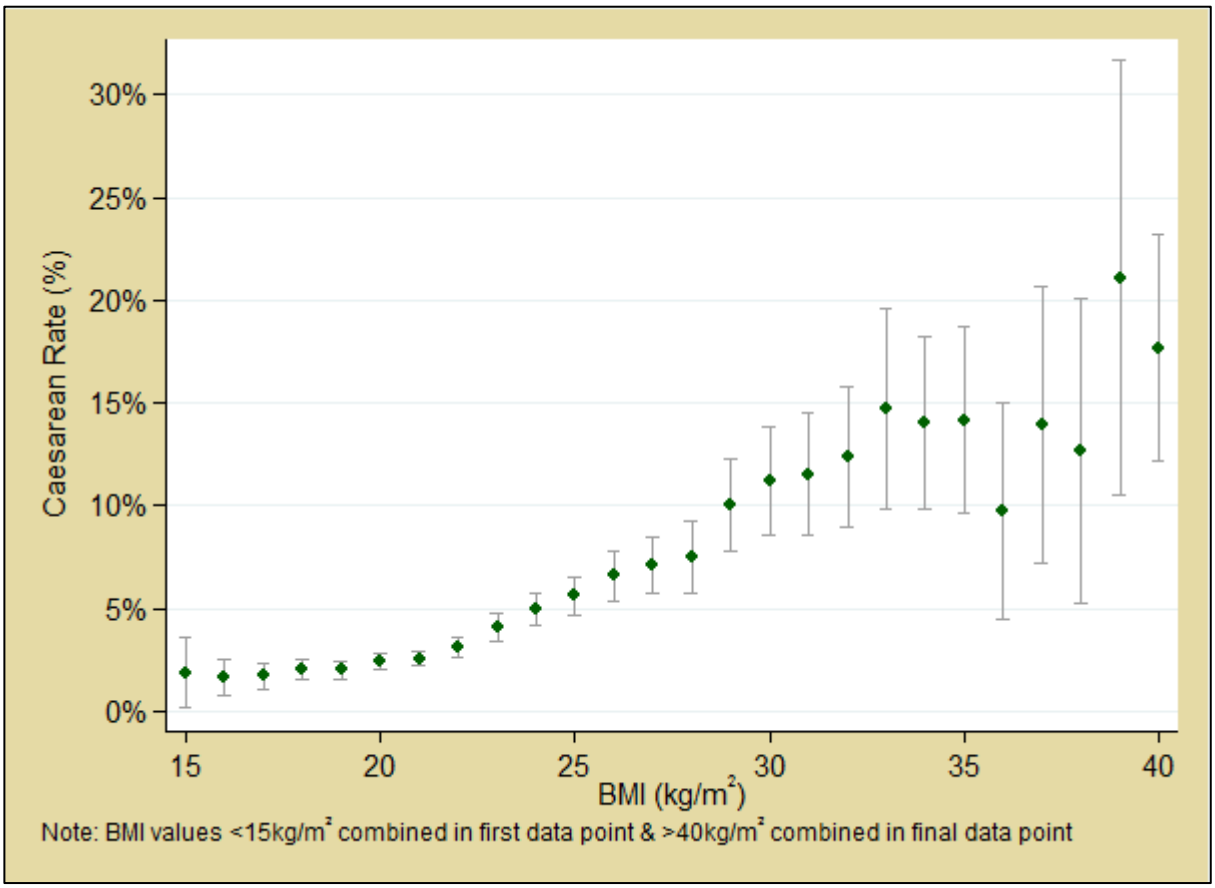

Table 1: Distribution of caesarean deliveries and maternal BMI categories in the sample n=153,102

Country (Year of Survey)	Unweighted N	Caesarean at Index Delivery	Maternal BMI Category					
			Underweight (<18.5 kg/m^2)	Optimal weight (18.5-24.9 kg/m^2)	Overweight (25-29.9 kg/m^2)	Obese Class I (30-34.9 kg/m^2)	Obese Class II (35-39.9 kg/m^2)	Obese Class III (≥40 kg/m^2)
Benin (2011-12)	7,142	6.2%	4.9%	67.8%	20.7%	4.3%	1.5%	0.8%
Burkina Faso (2010)	7,969	2.6%	14.1%	76.1%	7.3%	1.8%	0.7%	0.1%
Burundi (2010)	3,761	4.8%	12.5%	79.8%	5.8%	1.3%	0.2%	0.4%
Cameroon (2011)	5,487	5.1%	7.1%	60.0%	21.7%	8.0%	2.3%	0.9%
Chad (2004)	2,286	0.5%	21.8%	71.2%	5.3%	1.3%	0.4%	0.1%
Comoros (2012)	1,550	11.7%	3.5%	48.8%	30.7%	12.3%	3.2%	1.5%
Congo-Brazzaville (2011-12)	4,706	7.3%	12.9%	60.7%	18.0%	5.9%	2.2%	0.4%
Cote d'Ivoire (2011-12)	4,044	3.5%	5.0%	70.4%	18.2%	5.1%	0.8%	0.4%
Democratic Republic of Congo (2013-14)	7,902	6.3%	13.7%	70.4%	12.8%	2.4%	0.7%	0.1%
Ethiopia (2011)	5,933	2.1%	24.0%	71.4%	3.7%	0.7%	0.2%	0.0%
Gabon (2012)	2,897	11.1%	4.4%	48.5%	26.7%	13.0%	6.1%	1.3%
Ghana (2008)	1,695	7.2%	7.6%	61.9%	22.1%	5.7%	2.0%	0.6%
Guinea (2012)	3,606	3.0%	10.2%	70.5%	14.9%	3.1%	0.6%	0.6%
Kenya (2008-09)	3,143	7.1%	12.3%	64.7%	16.9%	4.9%	0.8%	0.4%
Lesotho (2009)	2,562	7.4%	3.8%	49.0%	29.0%	12.1%	4.3%	1.8%
Liberia (2013)	4,015	4.6%	5.8%	67.9%	18.2%	6.4%	0.9%	0.7%
Madagascar (2008-09)	6,333	1.9%	28.4%	66.2%	4.7%	0.6%	0.1%	0.0%
Malawi (2010)	10,630	5.1%	6.8%	75.9%	13.6%	3.1%	0.4%	0.2%
Mali (2012-13)	4,928	3.3%	9.2%	72.8%	13.3%	3.4%	0.7%	0.7%
Mozambique (2011)	5,525	4.7%	6.6%	78.7%	11.6%	2.3%	0.6%	0.2%
Namibia (2013)	3,235	15.6%	10.7%	56.0%	20.1%	9.5%	2.8%	1.0%
Niger (2012)	5,487	1.7%	12.6%	68.8%	14.5%	3.4%	0.6%	0.3%
Nigeria (2013)	14,674	2.7%	9.2%	65.0%	18.4%	5.2%	1.5%	0.7%
Rwanda (2010)	5,297	7.9%	5.4%	78.5%	13.7%	2.0%	0.3%	0.1%
Senegal (2010-11)	6,106	7.7%	18.6%	58.3%	16.5%	5.5%	0.8%	0.4%
Sierra Leone (2013)	6,462	4.2%	8.0%	74.8%	13.3%	3.0%	0.5%	0.5%
Swaziland (2005-06)	1,684	8.7%	1.5%	42.1%	31.5%	16.4%	5.8%	2.7%
Tanzania (2010)	4,080	6.0%	10.4%	69.5%	15.0%	4.1%	0.8%	0.3%
Uganda (2011)	3,518	6.6%	10.2%	71.7%	14.3%	3.4%	0.5%	0.0%
Zambia (2007)	2,988	3.9%	8.2%	73.8%	13.5%	3.3%	0.8%	0.4%
Zimbabwe (2010-11)	3,457	4.8%	6.3%	63.1%	21.9%	6.1%	2.0%	0.6%
Pooled, all Sub-Saharan Africa	**153,102**	**4.4%**	**11.9%**	**68.2%**	**14.6%**	**3.9%**	**1.0%**	**0.4%**

Sampling weights used for all percentages

Table 2: Unadjusted and adjusted logistic regression models for the effect of maternal BMI on the odds of caesarean delivery; n=153,102

		%	OR	95% CI	p-value	aOR*	95% CI	p-value
BMI Category	**Underweight**	11.9%	0.64	[0.53, 0.79]	<0.001	0.77	[0.63, 0.95]	<0.001
	Optimal	68.2%	1.00			1.00		
	Overweight	14.6%	2.41	[2.11, 2.75]		1.54	[1.33, 1.78]	
	Obese Class I	3.9%	4.27	[3.60, 5.06]		2.39	[1.96, 2.90]	
	Obese Class II	1.0%	4.81	[3.56, 6.51]		2.47	[1.78, 3.43]	
	Obese Class III	0.4%	7.31	[4.77, 11.21]		3.85	[2.46, 6.00]	
Previous caesarean	**No**	98.7%	1.00		<0.001	1.00		<0.001
	Yes	1.3%	41.93	[35.32, 49.79]		56.29	[44.57, 71.10]	
Maternal Age Group (years)	**20-24**	23.0%	1.00		<0.001	1.00		<0.001
	25-29	27.7%	1.12	[1.00, 1.25]		1.56	[1.32, 1.83]	
	30-34	21.0%	1.14	[1.02, 1.29]		2.32	[1.93, 2.77]	
	35-39	16.3%	1.20	[1.06, 1.36]		3.13	[2.51, 3.91]	
	40-44	8.6%	1.04	[0.88, 1.22]		4.29	[3.27, 5.64]	
	45-49	3.4%	0.69	[0.53, 0.89]		3.09	[2.14, 4.47]	
Area of Residence	**Rural**	71.1%	1.00		<0.001	1.00		0.008
	Urban	28.9%	3.25	[2.93, 3.60]		1.22	[1.05, 1.42]	
Relative Wealth Quintile	**Poorest**	20.9%	1.00		<0.001	1.00		<0.001
	Poorer	20.9%	1.51	[1.26, 1.80]		1.36	[1.09, 1.70]	
	Middle	19.7%	2.30	[1.94, 2.72]		1.78	[1.44, 2.21]	
	Richer	19.6%	3.17	[2.72, 3.71]		1.83	[1.48, 2.27]	
	Richest	19.0%	7.51	[6.46, 8.73]		2.73	[2.15, 3.45]	
Maternal Education	**No education**	40.5%	1.00		<0.001	1.00		<0.001
	Primary only	35.6%	2.10	[1.81, 2.42]		1.43	[1.21, 1.69]	
	Secondary or higher	23.9%	5.26	[4.61, 6.02]		1.75	[1.46, 2.11]	
Birth Order of Index Birth	**First birth**	13.9%	1.74	[1.57, 1.93]	<0.001	2.88	[2.50, 3.31]	
	2-3 previous births	33.7%	1.00			1.00		<0.001
	4-5 previous births	25.1%	0.68	[0.61, 0.77]		0.62	[0.53, 0.73]	
	>6 previous births	27.7%	0.47	[0.41, 0.53]		0.37	[0.30, 0.45]	
Time elapsed (mean months)		23	1.01	[1.01, 1.01]	<0.001	1.00	[1.00, 1.01]	0.009

**Adjusted for all other variables in model in addition to country of survey. Analysis adjusted for features of survey design (sampling weights, clustering, and stratification).*

Table 3: Comparison of the findings of this study with those from two previous systematic reviews

Maternal BMI Category	Chu et al (2007) (8)	Poobalan et al (2009) (9)		Pooled Sub-Saharan Results
		All Studies	Emergency Caesareans Only	
Optimal *(18.5-24.9 kg/m^2)*	1.00	1.00	1.00	1.00
Overweight *(25-29.9 kg/m^2)*	1.46 (1.34-1.60)	1.53 (1.48-1.58)	1.64 (1.55-1.73)	1.53 (1.33, 1.78)
Obese Class I *(30-34.9 kg/m^2)*	2.05 (1.86-2.27)	2.26 (2.04-2.51)	2.23 (2.07-2.42)	2.39 (1.96, 2.90)
Obese Class II *(35-39.9 kg/m^2)*	2.89 (2.28-3.79)	3.38 (2.49-4.57)		2.45 (1.78, 3.43)
Obese Class III *(≥40 kg/m^2)*				3.85 (2.46, 6.00)

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