Effect of maternal obesity on neonatal death in sub-Saharan Africa: multivariable analysis of 27 national datasets

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Summary

Background **Rates of obesity are increasing worldwide, including in sub-Saharan Africa. Neonates born to obese mothers in low-income settings are at increased risk of complications including admission to neonatal intensive care, macrosomia, low Apgar scores, and perinatal death. We investigated whether maternal obesity is a risk factor for neonatal death in sub-Saharan Africa and the effect on the detailed timing of death within the neonatal period.**

Methods **Cross-sectional Demographic and Health Surveys from 27 sub-Saharan countries (2003–09) were pooled. We used multivariable logistic regression to assess the risk of neonatal death (in women's most recent singleton livebirth in the 5 years preceding the survey) by maternal body-mass index (BMI) category (measured during the survey). Timing of death was investigated with a discrete-time survival model.**

Findings **15 518 of 81 126 eligible women were overweight (4266 were obese), 52 006 had an optimum BMI, and 13 602 were underweight. Maternal obesity was associated with an increased odds of neonatal death after adjustment for confounding factors (adjusted odds ratio 1·46, 95% CI 1·11–1·91). Maternal obesity was a significant risk factor for neonatal deaths occurring during the first 2 days of life (1·62, 1·11–2·37). We noted no statistically significant relation later in the neonatal period (days 2–6 1·36, 0·84–2·21; days 7–27 1·19, 0·65–2·18), possibly because of low statistical power.**

Interpretation **Maternal obesity in sub-Saharan Africa is associated with increased risk of early neonatal death. Potential mechanisms include prematurity, intrapartum events, or infections. Strategies to prevent and reduce obesity need to be considered; obese women should be advised to deliver in a health-care facility that can provide emergency obstetric and neonatal care.**

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Introduction

For many people, low-income countries are associated with images of starvation and hunger, yet obesity is a rapidly growing problem.[1–3] Ongoing global shifts in diet towards the consumption of high-fat and high-sugar foods, coupled with urbanisation and an increasingly sedentary lifestyle for many populations, are generating an upwards shift in body-mass index (BMI). In most low-income and middle-income countries, more women are overweight or obese (BMI≥25 kg/m²) than are underweight (BMI<18·5 kg/m²).[4] If secular trends continue, by 2030 there will be 185·8 million overweight or obese adults living in sub-Saharan Africa (28·7%), and 17·5% of adults will be obese.[5]

Neonates born to obese mothers are at increased risk of complications including admission to neonatal intensive care,[6] macrosomia,[7] low Apgar scores,[8] and perinatal death.[9] We know of no previous studies that have investigated the effect of maternal obesity on neonatal mortality in low-income countries, where the burden of neonatal mortality is greatest.[10] In such settings, the facilities available to manage high-risk births, such as the complications that commonly arise in babies of obese mothers, are often of poor quality or non-existent. As such, many complications that are treatable in a well equipped unit can often result in the death of the infant. Much of the improvement in neonatal mortality reported so far has been achieved by reduction of neonatal tetanus, rather than prevention of intrapartum-related deaths.[11] Our study aimed to investigate whether maternal obesity is a risk factor for neonatal death within the sub-Saharan context, and to investigate the association between maternal obesity and the timing of neonatal death.

Methods

Dataset

The Demographic and Health Surveys (DHS) are nationally representative cross-sectional household surveys that use a standardised questionnaire to facilitate between-country comparisons. DHS have been shown to be of high data quality, particularly for low-income settings.[12] To generate a large dataset with sufficient statistical power to investigate the effect of maternal obesity on the timing of neonatal death, we pooled data from the most recent survey in 27 countries in sub-Saharan Africa since 2000. The response rate was more than 90%. The outcome of the most recent livebirth for each woman within the 5 years preceding the survey was considered in the analysis (index birth). Multiple births were excluded.

The DHS collect detailed birth histories on livebirths for each woman; respondents were asked about the month and year of each birth, any multiple gestations, each child's vital status at the time of the interview, and either current age or age of death, as applicable. Age at death was recorded in days if the child died within the first month of life, in months if the child died between 1 month and their second birthday, or otherwise in years. This study used the WHO definition of neonatal death: the death of a liveborn infant during the first 28 completed days of life.

Weight and height were measured by interviewers during the survey with a standardised protocol.[12] BMI was calculated as weight (in kg) divided by height (in m²).

	n	Maternal BMI category, n (%)			
		Underweight (<18·5 kg/m²)	Optimum (18·5–24·9 kg/m²)	Overweight (25–29·9 kg/m²)	Obese (≥30 kg/m²)
Eastern Africa					
Ethiopia (2005)	2237	785 (33·5%)	1339 (63·1%)	86 (2·8%)	27 (0·7%)
Kenya (2008–09)	2809	513 (17·9%)	1600 (59·1%)	499 (17·6%)	197 (6·3%)
Madagascar (2008–09)	2765	928 (35·8%)	1665 (58·9%)	144 (4·5%)	28 (0·8%)
Malawi (2004)	4542	558 (12·4%)	3408 (74·6%)	479 (10·9%)	97 (2·1%)
Mozambique (2003)	4216	500 (12·4%)	3101 (74·6%)	474 (9·7%)	141 (3·4%)
Rwanda (2005)	2011	220 (10·9%)	1556 (78·0%)	212 (10·1%)	23 (1·1%)
Tanzania (2004)	3745	549 (12·3%)	2576 (71·1%)	455 (12·7%)	165 (3·9%)
Uganda (2006)	1115	221 (19·0%)	732 (64·7%)	120 (11·9%)	42 (4·3%)
Zambia (2007)	2653	333 (12·6%)	1830 (69·1%)	376 (13·9%)	114 (4·5%)
Zimbabwe (2005–06)	2843	334 (11·7%)	1802 (64·2%)	538 (18·1%)	169 (6·0%)
Eastern pooled	28 936	4941 (17·0%)	19 609 (68·4%)	3383 (11·3%)	1003 (3·3%)
Middle Africa					
Cameroon (2004)	1659	137 (8·6%)	1042 (62·6%)	350 (21·0%)	130 (7·8%)
Chad (2004)	1982	546 (28·5%)	1199 (63·9%)	182 (5·7%)	55 (1·9%)
Congo-Brazzaville (2005)	2289	379 (15·9%)	1292 (55·6%)	440 (20·1%)	178 (8·5%)
Democratic Republic of the Congo (2007)	1772	372 (21·6%)	1161 (66·7%)	195 (9·4%)	44 (2·3%)
Middle pooled	7702	1434 (19·0%)	4694 (61·8%)	1167 (14·0%)	407 (5·2%)
Southern Africa					
Lesotho (2004)	986	56 (5·6%)	510 (49·7%)	251 (26·4%)	169 (18·3%)
Namibia (2006–07)	2857	492 (16·1%)	1477 (52·0%)	528 (19·2%)	360 (12·9%)
Swaziland (2006)	1402	28 (2·0%)	552 (39·1%)	436 (31·7%)	386 (27·3%)
Southern pooled	5245	576 (10·3%)	2539 (48·0%)	1215 (23·9%)	915 (17·8%)
Western Africa					
Benin (2006)	6922	929 (13·0%)	4809 (68·9%)	856 (13·1%)	328 (5·1%)
Burkina Faso (2003)	4995	1396 (27·2%)	3221 (65·0%)	291 (6·0%)	87 (1·8%)
Ghana (2008)	1542	178 (10·8%)	913 (57·7%)	330 (22·9%)	121 (8·6%)
Guinea (2005)	1445	254 (16·8%)	1004 (69·2%)	149 (10·9%)	38 (3·1%)
Liberia (2007)	2631	338 (13·3%)	1751 (67·4%)	398 (13·9%)	144 (5·4%)
Mali (2006)	5515	817 (15·2%)	3596 (67·1%)	819 (13·2%)	283 (4·6%)
Niger (2006)	1836	336 (19·9%)	1108 (65·1%)	281 (11·5%)	111 (3·4%)
Nigeria (2008)	11 611	1983 (16·3%)	7105 (60·1%)	1885 (17·3%)	638 (6·3%)
Senegal (2005)	1467	250 (16·5%)	883 (59·5%)	229 (16·3%)	105 (7·8%)
Sierra Leone (2008)	1279	170 (13·7%)	774 (62·0%)	249 (18·7%)	86 (5·6%)
Western pooled	39 243	6651 (16·6%)	25 164 (64·3%)	5487 (14·0%)	1941 (5·1%)
All sub-Saharan Africa					
Pooled	81 126	13 602 (16·6%)	52 006 (64·5%)	11 252 (13·7%)	4266 (5·3%)

Sample weights used; unweighted count data (n) presented.

Table 1: **Distribution of maternal BMI category by country and region**

Standard classifications were used: underweight (<18·5 kg/m²), optimum (18·5–24·9 kg/m²), overweight (25–29·9 kg/m²), and obese (≥30 kg/m²).

Pre-pregnancy BMI was not available; therefore we assumed that maternal BMI category at the time of the survey was the same as that before the index birth. Women deemed likely to have had large changes in body size were excluded from the analysis—namely, those who were pregnant or less than 3 months post partum at the time of data collection, and adolescents (<20 years), since they might not have yet attained adult stature.

Statistical analysis

After preliminary exploration of the data, we used multivariable logistic regression to investigate the association between maternal BMI category and neonatal death, adjusted for the confounding factors specified a priori. Covariates included in the model were country, maternal age at the index birth (5-year age groups), urban or rural residence, relative asset index (wealth) quintile, maternal education, and birth order of the index birth. DHS conduct editing and imputation procedures before data are released. There were six missing values for maternal education; these cases were not included in the final models. Method of delivery of the index birth (vaginal or caesarean) was not adjusted for because we believe it is not a confounder but rather is an indicator of the mechanism through which obesity acts. We did explore this variable as part of understanding the causal pathway; we postulated that obesity would lead to complications that would in turn result in caesarean section and an increased risk of neonatal death.

The model was inspected for evidence of interaction between maternal BMI and maternal age group, and birth order with the Wald test. To examine the timing of death, Cox regression was used to obtain the daily hazard rate for infants during the first 28 completed days of life. Logistic regression was used to calculate the adjusted odds ratios for neonatal death within three discrete periods (days 0–1, 2–6, and 7–27); this analysis provides the odds of neonatal death within each discrete period, given that death has not already occurred.

To examine whether BMI changes after the index birth differ in women with live and deceased neonates, we regressed BMI on the time elapsed between the index birth and the survey. Time elapsed between the index birth and survey was controlled for in the multivariable models; the maximum possible time elapsed was 60 months.

Stata (version 11.0) was used for all analyses. Features of complex survey design were taken into account using Stata's svy suite of commands.

Role of the funding source

The sponsor of the study had no role in study design, data collection, data analysis, data interpretation, or

writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

81 126 women were eligible for the study (table 1). The smallest sample was from Lesotho and the largest was from Nigeria (table 1). 15 518 women had a BMI ≥25 kg/m² (4266 of whom were obese), 52 006 had optimum BMI, and 13 602 were underweight. The number of women overweight and obese ranged from 113 in Ethiopia to 822 in Swaziland. There were 1290 neonatal deaths in the sample, corresponding to a neonatal mortality rate of 16 per 1000 livebirths.

The unadjusted odds ratio (OR) suggested that the odds of neonatal mortality increased as maternal BMI increased. Compared with a baseline of optimum-weight mothers, infants born to both overweight and obese mothers had increased mortality (OR 1·26, 95% CI 1·05–1·51 for overweight; 1·51, 1·17–1·94 for obese), whereas we noted no difference in those born to underweight mothers (1·00, 0·83–1·21).

After adjustment for age group, urban or rural residence, relative wealth quintile, birth order, maternal education, and time elapsed since the index birth, infants born to both overweight and obese mothers remained at significantly increased odds of death compared with those born to mothers of optimum weight (table 2). We recorded no difference in the odds of neonatal death in those infants born to underweight mothers compared with those born to mothers of optimum weight (table 2). We detected no significant interaction between maternal BMI category and either age group (p=0·61) or birth order (p=0·42; data not shown).

Overall, 2813 women delivered by caesarean section. Rates of caesarean section were higher for obese mothers (11·8%) than for all other other BMI categories (underweight 1·9%; optimum 2·7%; overweight 6·7%). Births after caesarean section were associated with neonatal death (adjusted OR 2·69, 95% CI 2·06–3·52).

Figure 1 shows the smoothed hazard function for infants during the first month of life, stratified by maternal BMI and with all other covariates held at the mean value. As expected, the hazard was greatest early in the neonatal period for all infants. However, infants born to obese mothers had a greater excess hazard than did those born to women of optimum weight. This differential was maintained throughout the neonatal period (figure 1).

Table 3 shows the ORs for neonatal mortality according to maternal BMI within three discrete periods. Neonates born to overweight and obese women had increased odds of death compared with those born to optimum weight women during the first 2 days of life. We recorded no statistically significant relation later in the neonatal period (table 3).

Figure 2 shows BMI as a function of time since delivery, stratified by neonatal outcome. For women whose neonate survived, BMI was associated with an increase of 0·012 kg/m² for each additional month elapsed between the index birth and survey (p<0·0001). We recorded no significant association for those women whose baby died during the neonatal period, (0·009 kg/m² per month elapsed; p=0·2391). Furthermore, we noted no significant difference (p=0·9404) in the mean time elapsed for those who did not experience a neonatal death (22·36 months) and those whose baby died (22·32 months).

At 22·4 months after the index birth (the mean time elapsed) the predicted average gain in BMI was 0·27 kg/m² (95% CI 0·22 to 0·32) for those women who did not have a neonatal death and 0·20 kg/m² (–0·14 to 0·55) for those whose baby died. For women who gave

	n	Weighted percentage or mean value	Number of neonatal deaths	Adjusted OR* (95% CI)	p value
Maternal BMI category					
Underweight	13 602	16·6%	185	0·99 (0·81–1·20)	0·9118
Optimum	52 000	64·5%	786	1·00	..
Overweight	11 252	13·7%	215	1·22 (1·02–1·47)	0·0315
Obese	4266	5·3%	104	1·46 (1·11–1·91)	0·0062
Maternal age group (years)					
20–24	24 475	30·3%	338	1·00	..
25–29	22 538	27·8%	287	1·01 (0·83–1·24)	0·9256
30–34	16 524	20·5%	241	1·09 (0·85–1·39)	0·5046
35–39	11 482	13·9%	252	1·53 (1·17–2·01)	0·0019
40–44	5192	6·4%	133	1·85 (1·34–2·55)	0·0002
45–49	909	1·1%	39	2·88 (1·84–4·50)	<0·0001
Area of residence					
Rural	56 647	72·0%	884	1·00	..
Urban	24 473	28·0%	406	0·98 (0·82–1·18)	0·8271
Relative wealth quintile					
Poorest	17 358	20·9%	252	1·00	..
Poorer	16 269	20·3%	240	0·97 (0·79–1·19)	0·7395
Middle	16 363	20·3%	281	1·13 (0·92–1·39)	0·2317
Richer	16 020	19·9%	287	1·28 (1·03–1·59)	0·0290
Richest	15 110	18·7%	230	0·99 (0·74–1·31)	0·9198
Birth order					
First birth	8482	10·5%	177	1·78 (1·41–2·23)	<0·0001
Para 2–3	27 677	34·2%	319	1·00	..
Para 2–5	21 417	26·3%	302	1·07 (0·88–1·31)	0·4942
Para ≥6	23 544	28·9%	492	1·35 (1·06–1·72)	0·0134
Maternal education					
No education	37 362	45·7%	596	1·00	..
Primary only	26 388	32·8%	401	1·11 (0·93–1·33)	0·2338
Secondary or more	17 370	21·5%	293	1·12 (0·89–1·42)	0·3250
Time since index birth (months)	81 120	22·4	1290	1·00 (0·99–1·00)	0·2553

Sample weights used; unweighted count data (n) presented. BMI=body-mass index. OR=odds ratio. *Estimates adjusted for all other factors in table and for the dummy variable for country of survey.

Table 2: **Association of maternal BMI category and other sociodemographic characteristics with neonatal mortality at the most recent birth (n=81 120)**

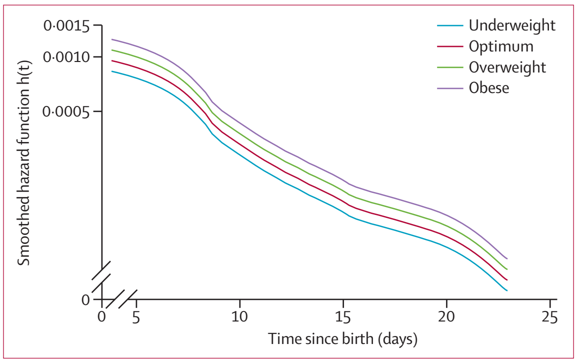

***Figure 1:* Daily hazard of death for infants during the first month of life, stratified by maternal body-mass index**
All covariates (maternal age group, urban or rural residence, relative wealth, maternal education, birth order, and time elapsed since index birth) held at the mean value. Epanechnikov kernal function used for smoothing.

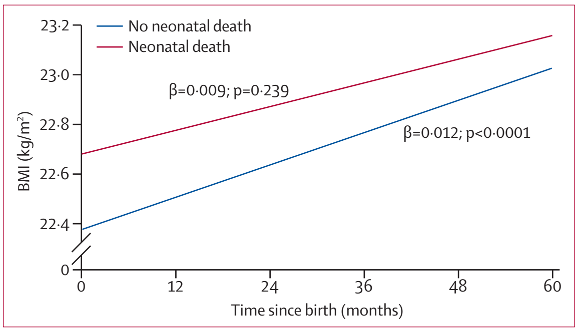

***Figure 2:* Association between BMI (as measured at the survey) and time elapsed between the index birth and survey, stratified by neonatal outcome**
Adjusted for age, parity, urban or rural residence, relative wealth, and maternal education. All covariates held at mean value. Survey design taken into account. BMI=body-mass index.

	Number of deaths	Adjusted OR (95% CI)	p value
Days 0–1			
Underweight	79	0·95 (0·71–1·29)	0·7609
Optimum	364	1·00	
Overweight	112	1·32 (1·01–1·72)	0·0395
Obese	57	1·62 (1·11–2·37)	0·0129
Days 2–6			
Underweight	55	0·94 (0·66–1·34)	0·7274
Optimum	225	1·00	
Overweight	59	1·22 (0·88–1·70)	0·2352
Obese	31	1·36 (0·84–2·21)	0·2057
Days 7–27			
Underweight	51	1·10 (0·77–1·57)	0·6035
Optimum	197	1·00	
Overweight	44	1·01 (0·69–1·47)	0·9787
Obese	16	1·19 (0·65–2·18)	0·5696

Estimates adjusted for maternal age group, urban or rural residence, relative wealth, birth order, maternal education, and time elapsed since index birth, and for the dummy variable for country of survey. BMI=body-mass index. OR=odds ratio.

***Table 3:* Association of maternal BMI category with neonatal mortality at the most recent birth, stratified by timing of neonatal death (n=81 120)**

birth the maximum possible time before the survey (60 months), we predicted an average increase of 0·72 kg/m² (0·59 to 0·85).

Discussion

Maternal obesity is associated with increased risk of neonatal death in sub-Saharan Africa; the effect is of a comparable magnitude to other risk factors (such as short maternal height and low maternal weight), previously reported in the *Lancet* series on neonatal survival.[10] Maternal obesity has not previously been recognised as a risk factor for neonatal death in this setting.

Neonatal mortality in this sample was 16 per 1000 livebirths and was associated with increased maternal BMI. After adjustment for covariates, maternal obesity was a significant risk factor for neonatal death. Maternal obesity was a significant risk factor during the first 2 days of life. The relation between maternal obesity and risk of neonatal death was not significant during the late neonatal period, possibly because of low statistical power. We noted no difference in the odds of deaths for neonates born to underweight women compared with those of optimum weight.

The primary strengths of this study were the availability of a large, nationally representative dataset providing sufficient power to investigate neonatal deaths in infants born to obese mothers in greater detail than had been attempted previously in low-income settings. Furthermore, height and weight data were measured by a trained fieldworker according to an established protocol. However, the results should be interpreted in view of several methodological limitations, some of which arose as a result of the cross-sectional design.

BMI should be measured before pregnancy or in the first trimester. These data are not available in the DHS, and we are not aware of any longitudinal data source for sub-Saharan populations that would enable research questions such as this to be addressed. Moreover, to obtain such data in the absence of large-scale population registers is a challenge, since even the largest DHS or health and demographic surveillance sites are too small to generate the sample sizes needed for such analysis. We attempted to address this limitation by excluding women who were likely to have had substantial fluctuations in BMI from the study. Furthermore we show, reassuringly, that the direction and magnitude of effect of BMI as a function of time elapsed between the index birth and survey is similar in women whose neonate died or survived, and would if anything have led to an underestimate of effect. These findings suggest that any misclassification bias of BMI status is likely to be small. Nevertheless, this absence of data remains a serious limitation of our study that cannot be circumvented without primary data collection.

Our sample does not represent all women of reproductive age. Since we excluded women who were pregnant or less than 3 months post partum at the time of the survey, women who rapidly became pregnant subsequent to the index birth will be under-represented. Obesity has been associated with delayed conception of up to 2 months in high-income settings,[13] although the mechanism is unclear. It could be due to interaction between biological and psychosocial factors, which may or may not be transferable to the sub-Saharan context. However, the small size of the effect and the consistency of our findings with those from previous studies make this notion an unlikely explanation for our results.

Information about the occurrence of neonatal death was based on maternal recall. The DHS have collected data in low-income settings by similar methods for more than two decades, and there has been a substantial improvement in the completeness and reliability of the age and date reporting over time.[14] However, stillbirths are omitted in most surveys. If an early neonatal death was misclassified as a stillbirth, either intentionally or accidentally, it would not be recorded. Such scenarios are very difficult to detect[10,15] and, if they occur differentially for obese women, could lead to spurious associations. Heaping in the date of death occurs where survey respondents have a preference for reporting events on certain rounded dates (for example one week); it can be quantified by calculation of the proportion of excess deaths occurring on particular days (namely day 7, 14, or 21).[16] Heaping only presented a misclassification threat in this study at day 7, since days 7–27 were combined within one category.

Although this study has presented the most detailed analysis of the relation between maternal BMI and neonatal mortality in low-income settings so far, it was constrained by the availability of variables. In particular, we would have liked to have had information about cause of death and HIV status.

Rates of obesity in sub-Saharan Africa are currently low by global standards. Overall, in this study 5% of women were obese, whereas in England 25% of adult women are currently obese.[17] However, there is substantial geographical variation within the region; prevalence of overweight and obesity in southern Africa is similar to that observed in Europe and North America. Furthermore, rates of obesity are projected to rise substantially in sub-Saharan Africa during the next two decades.[5]

Sub-Saharan Africa has the highest rates of neonatal mortality worldwide.[11] The *Lancet* series on neonatal survival[10] showed that short maternal height (<150 cm) and low maternal weight (<47 kg) are risk factors for neonatal death. In our study, we noted that maternal obesity increased the odds of neonatal death by a similar order of magnitude to the previous studies after adjustment for confounding factors. Maternal underweight did not significantly increase the risk of neonatal death in our study.

Few previous studies have examined the effect of maternal obesity and neonatal death (panel). A cohort study of singleton pregnancies in Denmark showed that maternal obesity more than doubled the odds of neonatal death (OR 2·6, 95% CI 1·2–5·8) compared with women of optimum weight; however, consistent with our findings, no significant effect was noted in overweight or underweight women.[18] Results from the Danish National Birth Cohort study[19] have shown that infants born to overweight mothers are at increased risk of neonatal death (overweight hazard ratio 1·7, 95% CI 1·2–2·5; obese hazard ratio 1·6, 95% CI 1·0–2·4). Infants born to morbidly obese mothers have three times the odds of dying during the early neonatal period (OR 3·41, 95% CI 2·07–5·63).[9] The effect of maternal obesity in our study seems to be slightly smaller in magnitude. However, present rates of obesity in Africa in sub-Saharan Africa remain low; most obese women in our study had BMI values around 30–35 kg/m² whereas values of more than 40 kg/m² are becoming increasingly common in Europe and the USA. We did not have sufficient power to specifically investigate neonatal mortality in morbidly obese (BMI >35 kg/m²) women.

A Swedish population-based cohort study of 167750 births did not show a significant association between early neonatal death (days 0–6) and obesity in women with a BMI of less than 19·9 kg/m² as the baseline group (OR 1·2; 95% CI 0·7–1·7), although the study might have been under-powered.[20] The Swedish study had only 309 cases[20] compared with 1290 deaths in this study. Maternal underweight has previously been associated with better pregnancy outcomes than for women of optimum weight.[21-22]

We postulated that caesarean section is a factor in the causal pathway between obesity and neonatal mortality. Caesarean section rates in this population were low overall, suggesting that most women probably receive this procedure in response to major obstetric complications, possibly the same underlying cause behind the increased odds of neonatal death detected in women who delivered by caesarean. However, evidence suggests that

Panel: **Research in context**

Systematic review

We searched PubMed for articles published up to April 18, 2012, in any language with the search terms "obesity" and ("neonatal" or "perinatal") and ("mortality" or "death"). Our search identified 272 citations, none of which investigated the effect of obesity on neonatal mortality in a low-income setting.

Interpretation

Evidence from high-income settings has shown that infants born to obese mothers are at increased risk of a range of complications, including death. However, this finding has never been investigated in the sub-Saharan context. Our study showed an association between maternal obesity and the death of the most recent infant during the neonatal period. If confirmed with longitudinal research, obese African women should be encouraged to lose weight before pregnancy and be strongly advised to deliver in a facility capable of providing emergency care.

caesarean section rates are higher in wealthy women, and some of these procedures are likely to be elective. In any case, the data suggest that obese women are more likely to have caesareans than women of optimum weight, and such procedures are associated with elevated risks of neonatal mortality.

In this study, we assessed the timing of death within the neonatal period in greater detail than previous studies. Maternal obesity seems to be most important as a risk factor early in the neonatal period. This finding could suggest intrapartum events as potential causes of death.[23] Alternatively, maternal obesity has been associated with increased preterm births, particularly preterm premature rupture of the membranes.[19] We had no information about cause of infant death. However, increased risk in the early neonatal period would be consistent with what is known about the effect of maternal obesity in high-income countries where maternal obesity is a risk factor for prolonged and obstructed labour,[24–26] increased admission to neonatal intensive care[6] and lower Apgar scores.[8]

More robust longitudinal studies are needed to establish a causal relation between maternal obesity and neonatal deaths. Future research should focus on the cause of death of these neonates. If the association is confirmed, the public health implications are that obese women should be strongly advised to deliver in a health facility capable of providing prompt emergency obstetric and neonatal care. As in the sub-Saharan context most obese women are from higher socioeconomic, urban, and educated groups, and are likely to have the capacity to act on this information if it is provided to them. A substantial proportion of the effect seen in our study could be attributable to the effect of maternal diabetes or hypertension, which are not measured in the DHS. Prevalence of diabetes is rising in Africa;[27–29] however, diabetes is not routinely screened for during antenatal care in this setting. Identification of obese women who are at high risk of adverse pregnancy outcomes could be a cost-effective prevention strategy, since only weighing scales and a height stick are required. Overweight women should be advised to lose weight before pregnancy. Research is underway in high-income countries into the prevention of excessive weight gain during pregnancy; such research could be considered in low-income settings, although ultimately policies that discourage population-level increases in BMI might be preferable.

Contributors

All authors contributed to the interpretation of findings and comments and writing of drafts. JC analysed the data and wrote the first draft of the paper.

Conflicts of interest

We declare that we have no conflicts of interest.

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References

1 Popkin BM. The nutrition transition in low-income countres—an emerging crisis. *Nutr Rev* 1994; **52:** 285–98.
2 Popkin BM. The nutrition transition: an overview of world patterns of change. *Nutr Rev* 2004; **62:** S140–43.
3 Prentice AM. The emerging epidemic of obesity in developing countries. *Int J Epidemiol* 2006; **35:** 93–99.
4 Mendez MA, Monteiro CA, Popkin BM. Overweight exceeds underweight among women in most developing countries. *Am J Clin Nutr* 2005; **81:** 714–21.
5 Kelly T, Yang W, Chen CS, Reynolds K, He J. Global burden of obesity in 2005 and projections to 2030. *Int J Obes* 2008; **32:** 1431–37.
6 Kalk P, Guthmann F, Krause K, et al. Impact of maternal body mass index on neonatal outcome. *Eur J Med Res* 2009; **14:** 216–22.
7 Ehrenberg HM, Mercer BM, Catalano PM. The influence of obesity and diabetes on the prevalence of macrosomia. *Am J Obstet Gynecol* 2004; **191:** 964–68.
8 Chen M, McNiff C, Madan J, Goodman E, Davis JM, Dammann O. Maternal obesity and neonatal Apgar scores. *J Matern Fetal Neonatal Med* 2010; **23:** 89–95.
9 Cedergren MI. Maternal morbid obesity and the risk of adverse pregnancy outcome. *Obstet Gynecol* 2004; **103:** 219–24.
10 Lawn JE, Cousens S, Zupan J, *Lancet* Neonatal Survival Steering Team. 4 million neonatal deaths: when? Where? Why? *Lancet* 2005; **365:** 891–900.
11 Lawn JE, Kerber K, Enweronu-Laryea C, Cousens S. 3.6 million neonatal deaths—what is progressing and what is not? *Semin Perinatol* 2010; **34:** 371–86.
12 Pullum TW. An assessment of the quality of data on health and nutrition in the DHS Surveys, 1993–2003. DHS Methodological Reports 6. Calverton, MD: Macro International Inc, 2008.
13 Gesink Law DC, Maclehose RF, Longnecker MP. Obesity and time to pregnancy. *Hum Reprod* 2007; **22:** 414–20.
14 Pullum TW. An assessment of age and date reporting in the DHS Surveys, 1985-2003. DHS Methodological Reports 5. Calverton, MD: Macro International Inc, 2006.
15 Lawn J, Shibuya K, Stein C. No cry at birth: global estimates of intrapartum stillbirths and intrapartum-related neonatal deaths. *Bull World Health Organ* 2005; **83:** 409–17.
16 Hill K, Choi Y. Neonatal mortality in the developing world. *Demogr Res* 2006; **14:** 429–52.
17 NHS Information Centre, Lifestyles Statistics. Statistics on obesity, physical activity and diet: England, 2010. Leeds: NHS Information Centre for Health and Social Care, 2010.
18 Kristensen J, Vestergaard M, Wisborg K, Kesmodel U, Secher NJ. Pre-pregnancy weight and the risk of stillbirth and neonatal death. *BJOG* 2005; **112:** 403–08.
19 Nohr EA, Vaeth M, Bech BH, Henriksen TB, Cnattingius S, Olsen J. Maternal obesity and neonatal mortality according to subtypes of preterm birth. *Obstet Gynecol* 2007; **110:** 1083–90.
20 Cnattingius S, Bergström R, Lipworth L, Kramer MS. Prepregnancy weight and the risk of adverse pregnancy outcomes. *N Engl J Med* 1998; **338:** 147–52.
21 Bhattacharya S, Campbell DM, Liston WA, Bhattacharya S. Effect of body mass index on pregnancy outcomes in nulliparous women delivering singleton babies. *BMC Public Health* 2007; **7:** 168.
22 Sebire NJ, Jolly M, Harris J, Regan L, Robinson S. Is maternal underweight really a risk factor for adverse pregnancy outcome? A population-based study in London. *BJOG* 2001; **108:** 61–66.
23 Lawn JE, Lee AC, Kinney M, et al. Two million intrapartum-related stillbirths and neonatal deaths: Where, why, and what can be done? *Int J Gynaecol Obstet* 2009; **107:** S5–19.
24 Cedergren MI. Non-elective caesarean delivery due to ineffective uterine contractility or due to obstructed labour in relation to maternal body mass index. *Eur J Obstet Gynecol Reprod Biol* 2009; **145:** 163–66.
25 Zhang J, Bricker L, Wray S, Quenby S. Poor uterine contractility in obese women. *BJOG* 2007; **114:** 343–48.
26 Verdiales M, Pacheco C, Cohen WR. The effect of maternal obesity on the course of labor. *J Perinat Med* 2009; **37:** 651–55.
27 Mbanya JC, Motala AA, Sobngwi E, Assah FK, Enoru ST. Diabetes in sub-Saharan Africa. *Lancet* 2010; **375:** 2254–66.
28 Levitt NS. Diabetes in Africa: epidemiology, management and healthcare challenges. *Heart* 2008; **94:** 1376–82.
29 Idemyor V. Diabetes in sub-Saharan Africa: health care perspectives, challenges, and the economic burden of disease. *J Natl Med Assoc* 2010; **102:** 650–53.