BMJ Global Health

Out of sight, out of mind? Evidence from cross-sectional surveys on hidden caesarean sections among women with stillbirths in Ghana, 2007 and 2017

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To cite: Zethof S, Christou A, Benova L, *et al*. Out of sight, out of mind? Evidence from cross-sectional surveys on hidden caesarean sections among women with stillbirths in Ghana, 2007 and 2017. *BMJ Global Health* 2023;**8**:e011591. doi:10.1136/bmjgh-2022-011591

Handling editor Seema Biswas

► Additional supplemental material is published online only. To view, please visit the journal online (http://dx.doi.org/10.1136/bmjgh-2022-011591).

Received 20 December 2022
Accepted 17 May 2023

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ABSTRACT

Background Caesarean section (CS) rates in women experiencing stillbirth have not been studied with nationally representative data. Two Ghana Maternal Health Surveys (GMHS) have captured pregnancy and mode of birth data for all women including those with stillbirths. We compared CS rates between women with live births and stillbirths, and identified socio-economic and pregnancy-related factors associated with CS in stillbirths.

Methods A population-based cross-sectional study was conducted in a pooled sample of 17 138 women who had given birth within 5 years preceding the 2007 and 2017 GMHS. CS rates were compared between women with stillbirths and very early neonatal deaths (SBVENDs) and women with live births who survived the first day. Bivariate and multivariable logistic regressions explored variables associated with CS. Effect modification of household's wealth and maternal educational level by birth outcome was assessed using multivariable logistic regression with interaction terms.

Results CS rate in women with SBVEND was 19.3% compared with 9.6% in women with live births who survived the first day (rate ratio 2.2; 95% CI 1.6 to 2.9). In multivariable analysis, attaining middle school compared with no formal education (adjusted OR, aOR 2.8; 95% CI 1.1 to 7.1), having had five or more births compared with nulliparity (aOR 3.7; 95% CI 1.3 to 10.7) and reporting prolonged or obstructed labour (aOR 3.3; 95% CI 1.3 to 8.3) were associated with CS in women with SBVEND. Higher household wealth and educational levels were associated with an increased risk of CS in both study groups, with no statistically significant difference in effect.

Conclusion Disaggregating CS rates by birth outcome revealed a high rate among women with SBVEND, twice the overall rate compared with live births. Exclusion of these 'hidden' CSs from rate calculations may lead to underestimation of (inter)national CS rates and potentially conceals CS overuse or misuse.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Caesarean section (CS) in women with stillbirth is generally contraindicated, as it exposes women to the risks of surgery without benefiting the child.
⇒ Population and facility-based studies show high CS rates in women experiencing stillbirth.

WHAT THIS STUDY ADDS

⇒ This study is the first to provide CS rates in women with stillbirth or very early neonatal death in a nationally representative sample.
⇒ We found a CS rate in Ghana in women with stillbirth or very early neonatal death of twice the rate in live births.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ We recommend that stillbirth data be used when calculating future national and global CS rates to include all women regardless of birth outcome in the denominator, instead of only women with live births.
⇒ Similar analysis should follow in nationally representative samples to unravel the scale of CS in women with stillbirth.

INTRODUCTION

Stillbirths are an important indicator of the quality of maternity care.[1] For international comparisons, the WHO defines stillbirth as the death of a fetus at or beyond a gestational age of 28 weeks and before birth.[2] Timely access to emergency caesarean section (CS), as part of comprehensive emergency obstetric care, may avert 75% of intrapartum stillbirths.[3] On the other hand, performing CS in women whose babies had already died at the time of deciding for surgery might be considered as surgery performed 'too much, too late'.[4] If performed without maternal indication, such procedures expose women to the risks of surgery without saving the life of the baby. This is important in all settings, but especially in sub-Saharan Africa, where 11 per 1000 women die following CS as a result of haemorrhage, sepsis and complications of anaesthesia.[5]

Little is known about CS rates in women experiencing stillbirth. Ninety-eight per cent of stillbirths happen in low-income and middle-income countries, where household surveys such as the Demographic and Health Surveys (DHSs) are the main source of data used to estimate national maternity care seeking and coverage of care.[1] Prior to 2022, in most of these household surveys women whose pregnancies ended in stillbirth were not asked about their maternity care-seeking and care content.[6] Therefore, for most stillbirths, no data pertaining to mode of birth are collected and CS in stillbirths are generally overlooked in calculations of national and global CS rates.[4]

Nevertheless, several smaller population-based and facility-based studies in sub-Saharan Africa, South America and South East Asia have included pregnancies ending in stillbirths in measurements of CS rates.[7–10] In facility-based studies from Zanzibar and Mozambique, more than 20% of women with stillbirth gave birth by CS, double the rates found in women with live births.[7 8] In terms of access to CS, this discrepancy in CS rates between live and stillbirths might indicate lack of timely emergency obstetric care, rather than no access at all.[11] This may be particularly relevant in women with a lower socioeconomic status, as they have a higher risk of stillbirth, while CS rates are generally found to be relatively low.[12 13]

The Ghana Maternal Health Surveys (GMHSs) are among the few DHS and household surveys that, in addition to live births, collected mode of birth data for women with stillbirths.[14–16] CS rates in women with stillbirths have not been reported in a nationally representative sample in Ghana. In this study, we used GMHS 2007 and 2017 to compare CS rates between women with stillbirths or very early neonatal deaths (SBVEND) and live births surviving the first day of life. Second, we aimed to identify socioeconomic and pregnancy-related factors associated with CS in women with stillbirths in Ghana. Finally, the effect of household wealth and maternal education on access to CS were compared between women with stillbirths and live births.

METHODS

This study was reported following the Strengthening the Reporting of Observational Studies in Epidemiology statement on reporting of cross-sectional studies (online supplemental file 1).[17]

Study design and data collection

A population-based cross-sectional study was conducted using data from GMHS 2007 and 2017.[18 19] GMHSs are cross-sectional, nationally representative household surveys, in which women of reproductive age (15–49 years) were interviewed about reproductive and maternal health topics, such as family planning, pregnancy, childbirth and postnatal care.[14 15] These were special surveys conducted in addition to the standard Ghana DHS survey with the main purpose to assess maternal mortality and causes of maternal deaths. We used GMHS, instead of standard DHS, because in this survey women with stillbirths were asked to answer questions about maternity care they received, including data about mode of birth. The standard DHS only included women with live births in the sample for maternity care questions. To date, in Ghana, only GMHSs for the years 2007 and 2017 were conducted.

To select samples of women of reproductive age for GMHS 2007 and 2017, two-stage stratified sampling procedures were performed (figure 1). First, clusters (geographical areas covering an estimated number of households) were selected using a predetermined sample size and probability proportional to size sampling in the ten administrative regions in Ghana, stratified in rural and urban areas. In GMHS 2007, half of the clusters were selected from three regions: Greater Accra, Ashanti and Eastern regions. This was due to a national programme aimed at reducing maternal mortality in these regions specifically. Second, a fixed number of households were selected in each cluster using systematic sampling. For GMHS 2007 and 2017, 10 370 and 25 062 women, respectively, were interviewed with response rates of 97% and 99%. Detailed description of sampling techniques and questionnaires can be found in the 2007 and 2017 GMHS reports.[14 15]

Participants

We included the most recent birth of all women who reported having given birth in the 5 years prior to GMHS 2007 or 2017, as maternity care data were collected only for women's most recent births. Multiple pregnancy (eg, twins) were considered as one birth in which mode of birth and birth outcome of the last born were used. Thereby, we maintained a one-to-one ratio of the number of mothers to births.

Study groups were defined according to birth outcome: women with SBVEND were compared with women with live births who survived the first day of life. VENDs are commonly defined as babies dying within the first day.[20] We combined women with SBVEND into one study group to reduce recall bias, because misclassification of stillbirths as VENDs are common in household surveys.[21 22] Up to one-fifth of stillbirths were previously found to be misclassified as VENDs.[21]

We defined stillbirth as a baby born dead at gestational age of 7 or more months and who had not cried, moved or breathed, based on responses to two questions in the pregnancy history: '*Was the baby born alive, born dead or did you have a miscarriage or abortion?*' and '*Did that baby cry, move or breathe when it was born?*'. VEND was defined as a baby born alive (who had cried, moved or breathed after birth), but where the mother responded 'no' and 'less than a day' when asked whether the child was still alive and how long it had been alive.

The sample of women with SBVEND and women with live births who survived the first day were used for calculation and comparison of CS rates. Women with SBVEND

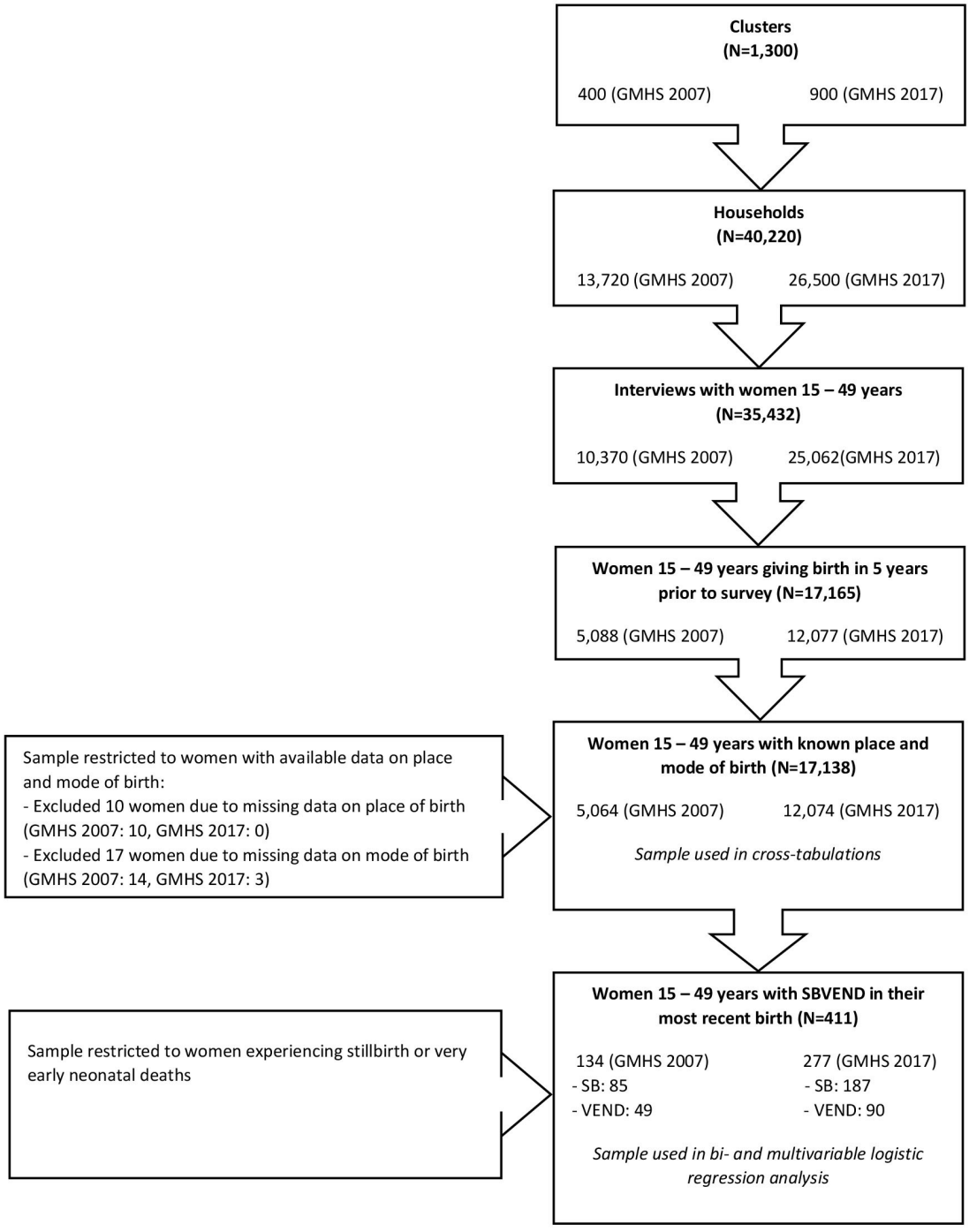

Figure 1 Flowchart with the derivation of the different study populations (unweighted). GMHS 2007 and 2017. GHMS, Ghana Maternal Health Survey; SB, stillbirth; SBVEND, stillbirth or VEND; VEND, very early neonatal deaths.

were analysed for factors associated with CS. Figure 1 shows the derivation of the different study populations displaying the unweighted number of participants.

Variables

The dependent variable was giving birth by CS. Women were asked where they had given birth and those giving birth in health facilities were subsequently asked if their child was '*delivered by caesarean (section), that is, did they cut your belly open to take the baby out?*'.

In addition to birth outcome, independent variables were considered based on their availability in both GMHS 2007 and 2017 and the effect of variables on CS in women with live births in previous studies.[23–28] We limited the number of included variables due to the small absolute number of CS in women with SBVEND, to maintain a ratio of one variable per five women.[29] In total, 17 variables were used, covering sociodemographic and pregnancy-related characteristics. Sociodemographic variables were ethnicity, region, place of residence, household's wealth

index, exposure to mass media, religion, marital status and maternal educational status. Pregnancy-related variables included maternal age and parity at index birth, history of perinatal death, multiple pregnancy, number of antenatal visits, antenatal care quality score, any peripartum complications, prolonged or obstructed labour and reduced fetal movements (online supplemental file 2). A number of categories per variable were limited to provide larger groups of women per category in accordance with our limited sample size. As two surveys were pooled in analysis, 'year of survey' was included as an additional variable.

Wealth index was a variable provided by DHS, generated from data on household assets, such as type of sanitation facilities available and households flooring material. Principal component analysis was used to assign a weight to each asset and, based on their score, households are divided in household wealth quintiles. We constructed 'exposure to mass media' as an additional variable, based on whether women read newspapers, listened to radio or watched television. No exposure at least once a week meant women were classified as 'little exposed', exposure to one out of three mass media as 'moderately exposed' and exposed to more than one classified as 'highly exposed'.[30] Additionally, an antenatal care quality score was constructed, composed of nine care items women during antenatal visits in the index pregnancy: measurement of maternal weight and blood pressure, analysis of urine and blood samples, education on danger signs and where to go for complications, if they received or were told to buy iron supplements, were given antihelminths and if they received tetanus vaccination. All nine items were scored binary, giving a maximum score of 9. Scores were dichotomised into low (0–7) and high[8 9] antenatal care quality. Cut-off was based on a mean antenatal care quality score of 7.4 from a prior analysis of GMHS 2017, with scores above average being considered high and scores below or equal to the mean being low.[31] Details of variables and their categorisation are available in online supplemental file 2.

Analysis

Analyses were performed using IBM SPSS Statistics, V.28. Data from GMHS 2007 and 2017 questionnaires were pooled to increase the sample size for analysis of the limited absolute number of CS in women with SBVEND. Women's sampling weights were applied to adjust for disproportionate sampling due to non-proportional allocation of selected households to regions and response rates. Sampling weights were denormalised to account for the difference in population size between surveys, using population data from the World Bank and the household population sample distribution from the corresponding GMHS (see online supplemental file 3).[14 15 32] SPSS complex sampling package was used to account for the GMHS's complex sampling design, implementing women's geographical area and cluster when calculating . GMHS survey reports did not provide information on cluster location. Therefore, in the complex sampling package, the 2007 and 2017 clusters were considered to be different, whereas geographical areas (strata) were considered similar. Apart from numbers regarding the study population in figure 1, all tables display weighted sample sizes.

We calculated the percentage and 95% CI of women that received four or more antenatal care visits (antenatal care coverage rate) and gave birth in facilities (facility birth rate), all births ending in SBVEND (SBVEND rate) and occurring by CS (CS rate). CS rates were stratified by birth outcome: SBVEND or liveborn surviving the first day. CS rates were compared between study groups using χ^2 tests to provide rate ratios (RR).

For women experiencing SBVEND, bivariate logistic regressions provided crude ORs (cOR) for each independent variables' category compared with a reference category. If five or fewer women per cell were observed, categories were collapsed.[33] Subsequently, multivariable logistic regression was used to identify risk factors for CS in women experiencing SBVEND. Multivariable analysis included independent variables based on statistical significance in bivariate logistic regression. Instead of p values below 0.05, variables with Wald F tests' p values below 0.25 in bivariate analysis were considered statistically significant, as to prevent exclusion of negatively correlated variables with a positive effect on outcome.[34] Pearson correlations above 0.8 or variance inflation factors higher than 4 were used to detect collinearity. The following independent variables were included: residence, wealth index, exposure to mass media, religion, current marital status, educational status, parity, history of perinatal death, multiple pregnancy, number of antenatal visits, antenatal care quality score, presence of peripartum complications, prolonged or obstructed labour and reduced fetal movements. To reduce overfitting, we used backward elimination based on p values to include eight independent variables in the final model, having a minimum of ten CS per included variable.[35] Adjusted ORs were provided (aOR). In bivariate and multivariable analyses, independent variables with an OR having a CI not containing the value 1 were considered statistically significant.

To assess effect modification by birth outcome (SBVEND or live birth who survived the first day) of household's wealth quintiles and maternal educational level on CS rates, we compared cORs using multivariable logistic regression with interaction terms. cORs were calculated for both independent variables' categories compared with reference categories in women with live births who survived the first day. These cORs were compared with cORs in women with SBVEND using multivariable logistic regression with interaction terms. aORs were provided as an effect size. Wald F tests of model effects were performed and p values below 0.05 indicated statistical significance.

As a sensitivity analysis, subgroup analysis was done in women with stillbirths. Bivariate and multivariable

logistic regression were performed similarly to the methodology described earlier. In assessing effect modification, women with VEND were included in the live births group. Online supplemental file 4 includes details on this analysis.

Missing data

Ten out of 17 165 women were excluded due to missing data on place of birth. Additionally, 17 women were excluded due to missing data on mode of birth. For each independent variable, missing values were less than 3%. Due to the limited number of women reporting SBVEND, missing values were manually imputed based on related variables to retain sample size. Online supplemental file 2 includes a detailed description of handling missing values.

Patient and public involvement

The importance of investigating use of CS and its associated morbidity in women with SBVEND was highlighted by clinical observations and informal conversations during clinical work by the authors with postpartum women in high-income and low-income settings. Patients were not actively involved in the design of our analysis of the GMHS data. However, prior to participation in GMHS, women were informed on the wide range of health topics of the survey and use of their responses to inform healthcare.[14] Specific components of the research partnership are defined in the author reflexivity statement (online supplemental file 5).

RESULTS

The final analysis included 17 138 women who had given birth in the 5 years prior to the surveys (table 1). Of those women, 411 reported experiencing SBVEND (2.6%, 95% CI 2.3% to 2.9%). Overall stillbirth rate was 1.7% or 17 stillbirths per 1000 total births, while the rate of VEND was 0.9% or 9 per 1000 total births. A higher SBVEND rate was found in women giving birth in facilities (3.0%; 95% CI 2.6% to 3.4%) compared with women giving birth at home (1.9%; 95% CI 1.4% to 2.4%). Of all women giving birth, 83.6% stated they had at least four antenatal care visits in the index pregnancy (95% CI 82.3 to 84.8). The pooled percentage of births occurring in health facilities was 67.7% (95% CI 65.4% to 69.9%).

In total, 9.9% of women reported giving birth by CS (95% CI 9.2 to 10.5). This was higher in the GMHS

Table 1 Stillbirth and very early neonatal death (SBVEND), antenatal care coverage, facility birth and CS rates (weighted)

	GMHS 2007 (N=7819)		GMHS 2017 (N=9319)		Total (N=17 138)	
	Cases/total births	% (95% CI)	Cases/total births	% (95% CI)	Cases/total births	% (95% CI)
SBVEND, antenatal care coverage and facility birth rates in the GMHS 2007 and 2017						
SBVEND in total	199/7819	2.5 (2.1 to 3.1)	249/9319	2.7 (2.3 to 3.1)	447/17 138	2.6 (2.3 to 2.9)
SB in total	130/7819	1.7 (1.3 to 2.2)	160/9319	1.7 (1.4 to 2.1)	290/1 7 138	1.7 (1.4 to 2.0)
VEND in total	69/7819	0.9 (0.6 to 1.2)	88/9319	0.9 (0.7 to 1.2)	157/17 138	0.9 (0.8 to 1.1)
SBVEND in home/other	60/3566	1.7 (1.2 to 2.4)	43/1972	2.2 (1.6 to 3.0)	103/5538	1.9 (1.4 to 2.4)
SBVEND in facility	139/4253	3.3 (2.6 to 4.1)	206/7347	2.8 (2.4 to 3.3)	345/11 600	3.0 (2.6 to 3.4)
In public facility	120/3399	3.5 (2.8 to 4.5)	189/6298	3.0 (2.5 to 3.5)	309/9697	3.2 (2.8 to 3.7)
In private facility	19/854	2.2 (1.2 to 3.9)	17/1049	1.6 (0.9 to 2.8)	36/1903	1.9 (1.3 to 2.8)
Antenatal care coverage	5991/7819	76.6 (74.2 to 78.9)	8337/9319	89.5 (88.5 to 90.3)	14328/17 138	83.6 (82.3 to 84.8)
In SBVEND	141/199	71.0 (61.2 to 79.2)	211/249	85.1 (79.5 to 89.3)	353/447	78.8 (73.4 to 83.4)
Births in facility	4253/7819	54.4 (50.4 to 58.3)	7347/9319	78.8 (77.0 to 80.5)	11600/17 138	67.7 (65.4 to 69.9)
In public facility	3399/7819	43.5 (39.9 to 47.1)	6298/9319	67.6 (65.7 to 69.4)	9697/17 138	56.6 (54.4 to 58.7)
In private facility	854/7819	10.9 (9.3 to 12.7)	1049/9319	11.3 (10.1 to 12.5)	1903/17 138	11.1 (10.2 to 12.1)
CS rates in the GMHS 2007 and 2017						
CS in total	513/7819	6.6 (5.7 to 7.5)	1175/9319	12.6 (11.7 to 13.5)	1688/17 138	9.9 (9.2 to 10.5)
CS in liveborn	481/7620	6.3 (5.5 to 7.2)	1121/9070	12.4 (11.5 to 13.3)	1602/16 691	9.6 (8.9 to 9.3)
CS in SBVEND	32/199	16.2 (10.5 to 24.3)	54/249	21.7 (16.2 to 28.4)	86/447	19.3 (15.1 to 24.3)
CS in SB	24/130	18.4 (10.9 to 29.4)	39/160	24.2 (17.3 to 32.6)	63/290	21.6 (16.2 to 28.1)
CS in VEND	8/69	12.1 (5.1 to 26.0)	15/88	17.3 (9.2 to 30.2)	23/157	15.0 (9.0 to 23.9)
CS in facility	513/4253	12.1 (10.6 to 13.7)	1175/7347	16.0 (15.0 to 17.1)	1168/11 600	14.6 (13.7 to 15.5)
In public facility	417/3399	12.3 (10.7 to 14.0)	994/6298	15.8 (14.6 to 17.0)	1411/9697	14.5 (13.6 to 15.6)
In private facility	96/854	11.3 (8.1 to 15.4)	181/1049	17.3 (14.7 to 20.2)	277/1626	14.6 (12.5 to 16.9)

GMHS 2007 and 2017.
CS, caesarean section; GMHS, Ghana Maternal Health Survey; SB, stillbirth; VEND, very early neonatal death.

2017—12.6% (95% CI 11.7% to 13.5%) compared with 6.6% (95% CI 5.7% to 7.5%) in the GMHS 2007. Table 1 shows that in the pooled study population 9.6% of women with live births who survived the first day (95% CI 8.9 to 9.3) and 19.3% of women with SBVEND (95% CI 15.1 to 24.3) gave birth by CS.

RRs of CS in women with SBVEND compared with women with live births who survived the first day

Among women with SBVEND, overall CS rate was 2.2 (95% CI 1.6 to 2.9) times higher than in women with live births who survived the first day (table 2). The highest prevalence of CS in women with SBVEND was found in multiple gestation births (29.3%), those with prolonged or obstructed labour (46.3%) or with reduced fetal movements (32.8%).

When examined according to sociodemographic and maternal characteristics, women with SBVEND had higher risks for caesarean birth than women with live births surviving the first day for most categories (table 2). They had a considerably higher risk of CS if they were of Mole-Dagbani ethnicity (RR 3.2; 95% CI 1.4 to 7.6), from the Northern regions (RR 3.1; 95% CI 1.2 to 7.7), of middle wealth (RR 3.1; 95% CI 1.8 to 5.4), of Muslim faith (RR 3.6; 95% CI 2.0 to 6.3) or belonged to other non-Christian religions or were areligious (RR 5.5; 95% CI 1.7 to 14.1), if they had some primary education (RR 3.7; 95% CI 1.9 to 7.2) or had five or more births (RR 3.6; 95% CI 2.2 to 5.9).

Bivariate and multivariable logistic regression of variables' association with CS in women with SBVEND

Table 3 shows the results of both bivariate and multivariable analyses of variables' association with CS in the 447 women experiencing SBVEND. Independent variables providing cORs with a CI not containing the value 1 in bivariate analysis were being from a household in the richest two wealth quintiles (cOR 2.9; 95% CI 1.4 to 5.9), being highly exposed to mass media (cOR 3.0; 95% CI 1.1 to 7.9), having had five or more births (cOR 2.6; 95% CI 1.1 to 6.6), having had four or more antenatal care visits (cOR 4.3; 95% CI 1.3 to 14.3) and having had prolonged or obstructed labour (cOR 4.3; 95% CI 1.8 to 10.2). In multivariable regression, having attained middle school level education (aOR 2.8; 95% CI 1.1 to 7.1), having had five or more births (aOR 3.7; 95% CI 1.3 to 10.7) and reporting having had prolonged or obstructed labour (aOR 3.3; 95% CI 1.3 to 8.3) were associated with CS in women experiencing SBVEND.

Multivariable logistic regression with interaction terms evaluating effect modification by birth outcome of household wealth status and maternal educational level on CS

Women with SBVEND who were from households in the median wealth quintile had an cOR of 2.2 (95% CI 1.0 to 4.8) of having CS as compared with women in the poorest two quintiles (table 4). In women with live births, this cOR was 1.7 (95% CI 1.4 to 2.1). When comparing these cORs using multivariable analysis with interaction terms, no statistically significant effect modification by birth outcome was found, providing an aOR of 1.3 (95% CI 0.6 to 3.0). Additionally, women with SBVEND who were from the richest two quintiles had an cOR of 2.9 (95% CI 1.4 to 5.9) of having CS as compared with women in the poorest two quintiles. In women with live births, this cOR was 3.9 (95% CI 3.3 to 4.6), which did not differ with statistical significance from the cOR found in women with SBVEND (aOR 0.7, 95% CI 0.4 to 1.6). The overall Wald F p value for effect modification of household's wealth status by birth outcome was 0.33, indicating no statistically significant difference in wealth's effect on CS between SBVEND and live births.

Regarding maternal educational level, women with SBVEND having attained secondary or higher education had an cOR of 2.6 (95% CI 1.0 to 6.7) of having CS as compared with women with no formal education (table 4). In women with live births who survived the first day, this cOR was 5.1 (95% CI 4.1 to 6.4). In multivariable analysis with interaction terms, these cORs did not differ with statistical significance (aOR 0.5, 95% CI 0.2 to 1.3). The effect of education on having CS was also found to be similar between study groups when comparing women with primary or middle education with women without formal education. This provided a Wald F p value 0.17, indicating no statistical significant effect modification by birth outcome of maternal educational level on CS.

Subgroup analysis

Two-hundred and twenty-nine women with stillbirths were included in a subgroup analysis (online supplemental file 4). Bivariate logistic regression showed cORs similar to women with SBVEND. AORs differed from women with SBVEND, with multiple pregnancy (aOR 3.6, 95% CI 1.6 to 8.4) and higher number of antenatal care visits (aOR 3.9, 95% CI 1.3 to 11.8) having statistically significant positive associations with CS.

DISCUSSION

To our knowledge, this is the first nationally representative study on CS rates in women with stillbirths. We found a CS rate of 19% among women with SBVEND, more than double the rate of women with live births who survived the first day of life. Disaggregating CS rates by birth outcome revealed much higher use of CS among women experiencing SBVEND, which otherwise would have remained hidden. This difference in rates between women with stillbirths and live births may potentially indicate CS overuse or misuse and exclusion of these hidden CS from CS rate calculations may lead to underestimation of national and global CS rates.

In women with intrauterine fetal deaths, CS should only be performed to manage severe maternal complications of pregnancy. In the absence of maternal indications, women should not be exposed to the risks of surgery without the option to save the life of the child.

Table 2 Caesarean section (CS) rates in women with stillbirth or a very early neonatal deaths and women with live births who survived the first day (N=17 138) (weighted)

	Stillbirths and very early neonatal deaths (N=447)			Live births who survived the first day (N=16691)			
	CS N	Total N	CS rate %	CS N	Total N	CS rate %	RR (95% CI)*
Total	86	447	19.3	1602	16691	9.6	2.2 (1.6 to 2.9)
Year of survey							
2007	32	198	16.2	481	7621	6.3	2.8 (1.7 to 4.8)
2017	54	249	21.7	1121	9070	12.4	1.9 (1.4 to 2.7)
Ethnicity							
Akan	47	243	19.3	864	7717	11.2	1.9 (1.3 to 2.7)
Ewe	12	49	24.6	261	2147	12.1	2.3 (1.0 to 5.3)
Mole-Dagbani	10	56	18.5	163	2515	6.5	3.2 (1.4 to 7.6)
Other	17	99	17.0	314	4312	7.3	2.5 (1.3 to 5.1)
Region							
Coastal	36	163	21.9	800	6939	11.5	2.1 (1.3 to 3.4)
Middle	43	225	19.3	602	6636	10.1	2.0 (1.4 to 3.0)
Northern	7	58	12.0	129	3116	4.1	3.1 (1.2 to 7.7)
Residence							
Rural	38	243	15.4	566	9680	5.8	2.8 (1.8 to 4.4)
Urban	49	205	23.8	1036	7011	14.8	1.8 (1.2 to 2.6)
Household's wealth index							
Poor	20	177	11.1	340	7153	4.8	2.4 (1.4 to 4.2)
Middle	22	101	21.7	261	3343	7.8	3.1 (1.8 to 5.4)
Rich	45	170	26.4	1001	6195	16.2	1.8 (1.2 to 2.8)
Exposure to mass media							
Little exposed	10	81	12.1	250	4380	5.7	2.2 (0.9 to 5.3)
Moderately exposed	24	187	13.0	525	6276	8.4	1.6 (1.0 to 2.6)
Highly exposed	52	179	29.0	827	6034	13.7	2.5 (1.6 to 3.7)
Maternal age							
<20	3	39	8.1	120	1846	6.5	1.3 (0.2 to 6.5)
20–35	54	261	20.6	1108	11578	9.6	2.4 (1.7 to 3.4)
>35	30	148	20.0	374	3266	11.4	1.9 (1.1 to 3.3)
Religion							
Christian	61	327	18.7	1338	12562	10.7	1.9 (1.3 to 2.7)
Muslim	20	81	24.2	230	2946	7.8	3.6 (2.0 to 6.3)
Other	5	38	14.1	34	1183	2.9	5.5 (1.7 to 14.1)
Current marital status							
Married or living together	72	361	20.0	1365	14171	9.6	2.3 (1.6 to 3.1)
Not married or living together	14	86	16.2	237	2520	9.4	1.8 (0.9 to 3.5)
Maternal educational status							
None	13	116	10.8	219	4784	4.6	2.4 (1.4 to 4.6)
Primary	32	93	24.1	244	3289	7.4	3.7 (1.9 to 7.2)
Middle	35	172	20.4	700	6398	10.0	2.0 (1.3 to 3.1)
Secondary or higher	16	66	24.3	439	2221	19.8	1.3 (0.6 to 2.6)
Parity							
0	10	94	10.3	456	3783	12.1	0.8 (0.4 to 1.7)
1–4	47	226	20.7	947	10114	9.4	2.5 (1.7 to 3.6)

Continued

Table 2 Continued

	Stillbirths and very early neonatal deaths (N=447)			Live births who survived the first day (N=16691)			
	CS N	Total N	CS rate %	CS N	Total N	CS rate %	RR (95% CI)*
≥5	30	128	23.4	199	2794	7.1	3.6 (2.2 to 5.9)
History of perinatal death							
No	56	323	17.3	1373	14985	9.2	2.0 (1.4 to 2.9)
Yes	30	124	24.4	229	1705	11.6	2.0 (1.2 to 3.2)
Multiple pregnancy							
No	75	408	18.3	1526	16324	9.3	2.1 (1.6 to 2.9)
Yes	11	39	29.3	76	367	20.7	1.5 (0.6 to 3.6)
No of antenatal care visits							
None	2	35	4.6	9	492	1.7	2.7 (0.3 to 21)
1–3	4	60	7.5	68	2224	3.1	2.5 (0.5 to 12.3)
≥4	80	352	22.7	1525	13957	10.9	2.4 (1.8 to 3.3)
Antenatal care quality score							
Low (0–7)	25	165	15.2	373	5531	6.7	2.4 (1.4 to 4.1)
High (8–9)	61	282	21.6	1229	11160	11.0	2.2 (1.6 to 3.0)
Peripartum complications							
No	44	283	15.5	1084	13528	8.0	2.1 (1.4 to 3.0)
Yes	42	164	25.8	518	3163	16.4	1.7 (1.1 to 2.7)
Prolonged or obstructed labour							
No	67	406	16.5	1475	16295	9.1	1.9 (1.4 to 2.7)
Yes	19	41	46.3	127	396	32.1	1.7 (0.8 to 3.6)
Reduced fetal movements							
No	79	426	18.6	1592	16650	9.6	2.1 (1.6 to 2.8)
Yes	7	21	32.8	10	41	23.8	1.3 (0.5 to 3.3)

Ghana Maternal Health Survey 2007 and 2017.
*RR dividing the CS rate in women with stillbirth or very early neonatal deaths by the CS rate in women with live births surviving the first day.
RR, rate ratio.

When fetal heart sounds were heard, stillbirth or neonatal death following CS could have followed difficult clinical judgement and a reasonably well-founded attempt to save the child's life that did not succeed. Considering such attempts as 'too much, too late' would disregard the complexity of clinical decision-making during obstetric emergencies and would wrongly suggest all CS in women with VEND are avoidable. However, even when death follows a genuine attempt to save the baby's life, some CS or deaths might have been prevented by adequate fetal heart rate monitoring, timely usage of assisted-vaginal birth and prompt performance of high-quality surgery to reduce the decision-to-incision interval. Therefore, use of CS in women with SBVEND may serve as an indicator of insufficient quality of emergency obstetric care.

Similar to our study, high CS rates in women with SBVEND were reported in facility-based studies in low-resource settings. In Mozambique, women experiencing stillbirth in health facilities had a CS rate of 43%, compared with 17% in live births.[8] A CS rate of 26% among stillbirths was found in a referral hospital on Zanzibar, which was double the rate found among live births.[7] Population-based studies, such as the Global Network study, reported lower CS rates, probably due to the inclusion of stillbirths born from 20 weeks' gestation onward.[9 10] These 'early' stillbirths are much less likely to be born by CS. Notably, in the Global Network study, 90% of non-macerated stillbirths were born by CS, suggesting fetal death had occurred shortly before surgery.[9]

Among women living in the Northern region, who are Muslim or belonged to the Mole-Dagbani ethnic group, CS rates were three times higher among SBVEND compared with live births. These characteristics are common to the same group of women, as the people of Dagbon are mainly situated in Northern Ghana and are predominantly Muslim.[36] The high CS rates in this group among women with SBVEND could be explained by limited access to care due to fewer health facilities and doctors in northern regions of Ghana.[37] Inaccessibility of emergency obstetric care is supported by a higher

Table 3 Bivariate and multivariable logistic regression of variables associated with caesarean section (CS) in women with stillbirth or a very early neonatal deaths (N=447) (weighted)

	Stillbirths and very early neonatal deaths (N=447)			
	CS (N=86)	VB (N=361)	cOR (95% CI)	aOR (95% CI)
Year of survey				
2007	32	166	1	
2017	54	195	1.4 (0.8 to 2.7)	
Ethnicity				
Akan	47	196	1	
Ewe	12	37	1.4 (0.5 to 3.5)	
Mole-Dagbani	10	46	1.0 (0.5 to 3.5)	
Other	17	82	0.8 (0.4 to 1.9)	
Region				
Coastal	36	127	1	
Middle	43	182	0.8 (0.4 to 1.6)	
Northern	7	51	0.5 (0.2 to 1.4)	
Residence*				
Rural	38	205	1	
Urban	49	156	1.7 (0.9 to 3.1)	
Household's wealth index*				
Poor	20	157	1	
Middle	22	79	2.2 (1.0 to 4.8)	
Rich	45	125	2.9 (1.4 to 5.9)	
Exposure to mass media*				
Little exposed	10	71	1	1
Moderately exposed	24	163	1.1 (0.4 to 3.0)	1.0 (0.3 to 2.8)
Highly exposed	52	127	3.0 (1.1 to 7.9)	2.1 (0.8 to 5.8)
Maternal age				
<35	57	243	1	
≥35	30	118	1.1 (0.6 to 2.0)	
Religion*				
Christian	61	266	1	1
Muslim, other religions, areligious	25	95	1.2 (0.6 to 2.2)	1.7 (0.8 to 3.8)
Current marital status*				
Married or living together	72	289	1	1
Not married or living together	14	72	0.8 (0.4 to 1.7)	0.6 (0.3 to 1.3)
Maternal educational status*				
None	13	103	1	1
Primary	32	71	2.6 (1.0 to 6.6)	2.7 (1.0 to 7.6)
Middle	35	137	2.1 (1.0 to 4.4)	2.8 (1.1 to 7.1)
Secondary or higher	16	50	2.6 (1.0 to 6.7)	3.3 (0.9 to 13.1)
Parity*				
0	10	84	1	1
1–4	47	179	2.3 (1.0 to 5.1)	2.3 (0.9 to 6.0)
≥5	30	98	2.6 (1.1 to 6.6)	3.7 (1.3 to 10.7)
History of perinatal death*				
No	56	267	1	
Yes	30	94	1.5 (0.8 to 3.0)	

Continued

Table 3 Continued

	Stillbirths and very early neonatal deaths (N=447)			
	CS (N=86)	VB (N=361)	cOR (95% CI)	aOR (95% CI)
Multiple pregnancy*				
No	75	333	1	1
Yes	11	28	1.8 (0.7 to 4.7)	1.9 (0.7 to 4.8)
No of antenatal visits*				
<4	6	89	1	1
≥4	80	272	4.3 (1.3 to 14.3)	3.8 (0.5 to 31.4)
Antenatal care quality score*				
Low (0–7)	25	140	1	
High (8–9)	61	221	1.5 (0.8 to 2.9)	
Peripartum complications*				
No	44	239	1	
Yes	42	122	1.9 (1.0 to 3.5)	
Prolonged or obstructed labour*				
No	67	339	1	1
Yes	19	22	4.3 (1.8 to 10.2)	3.3 (1.3 to 8.3)
Reduced fetal movements*				
No	79	347	1	
Yes	7	14	2.1 (0.6 to 7.7)	

Ghana Maternal Health Survey 2007 and 2017.
*Factors associated with CS in women having stillbirths and very early neonatal deaths with a Wald F-test p<0.25.
aOR, adjusted OR; cOR, crude OR; VB, vaginal birth.

maternal mortality ratio in the Northern compared with the middle and coastal regions.[15] Limited access to surgery might, apart from an absolute reduction in CS, lead to CS being performed too late, resulting in higher risks of stillbirth or perinatal asphyxia with VEND.[11]

Contrary to the increased risk of CS in multiparous women who experienced SBVEND in our study, previous findings show multiparity to be associated with reduced risks of CS in women with live births.[28] This difference might be explained by differing indications for CS

Table 4 Multivariable logistic regression with interaction terms assessing effect modification by birth outcome of household's wealth status and maternal educational level on caesarean section (CS) rates (N=17 138) (weighted)

	Stillbirths and very early neonatal deaths (N=447)			Live births who survived the first day (N=16691)			Wald F* and aOR (95% CI)†
	CS (N=86)	VB (N=361)	cOR (95% CI)	CS (N=1602)	VB (N=15089)	cOR (95% CI)	
Household's wealth index							0.33
Poor	20	157	1	340	6813	1	
Middle	22	79	2.2 (1.0 to 4.8)	261	3082	1.7 (1.4 to 2.1)	1.3 (0.6 to 3.0)
Rich	45	125	2.9 (1.4 to 5.9)	1001	5194	3.9 (3.3 to 4.6)	0.7 (0.4 to 1.6)
Maternal educational status							0.17
None	13	103	1	219	4565	1	
Primary	32	71	2.6 (1.0 to 6.6)	244	3045	1.7 (1.3 to 2.1)	1.6 (0.6 to 4.0)
Middle	35	137	2.1 (1.0 to 4.4)	700	5698	2.6 (2.1 to 3.1)	0.8 (0.4 to 1.8)
Secondary or higher	16	50	2.6 (1.0 to 6.7)	439	1782	5.1 (4.1 to 6.4)	0.5 (0.2 to 1.3)

Ghana Maternal Health Survey 2007 and 2017.
*Wald F p value serving as a measure of statistical significance. A p<0.05 is considered statistically significant.
†aOR and 95% CIs serve as a measure of effect size of effect modification by birth outcome.
aOR, adjusted OR; cOR, crude OR; VB, vaginal birth.

between nulliparous and multiparous women. Considering all CS performed in nulliparous, most are due to prolonged labour, while in multiparous women higher percentages are due to (pre)eclampsia, placental abruption and placenta praevia.[38] The latter indications have higher risks of SBVEND.

The relationship between prolonged labour and CS is easily understood, prolonged labour being an obstetric condition that may result in uterine rupture, stillbirth or perinatal asphyxia. In obstructed labour, CS and symphysiotomy are the only methods available to give birth. When a fetal heart rate is present, such invasive procedures might be justified after informed consent has been provided by the mother. When fetal death has been confirmed, however, alternative options for birth could be considered, such as induction of labour or assisted vaginal birth in case of prolonged labour, and destructive operative vaginal birth in case of obstructed labour. These options may reduce CS rates in women experiencing fetal death, protecting them from its morbidity and mortality.

In Ghana, higher wealth status and educational level were associated with an increased prevalence of CS in women with live births.[13 39] In the current study, similar associations were seen in both women with live births and SBVEND, with higher CS rates among the richest two wealth quintiles and higher education levels. The effect of wealth and educational level on CS did, however, not differ with statistical significance between study groups. This suggests that more CS rates are performed in women from richer households, whether the child is alive after birth or not. Questions could be raised about the necessity of many of these CS, possibly being a form of 'too much, too soon' or, even worse, 'too much, too late'.[4 40] We were unable to differentiate between emergency and elective CS, as the GMHS 2007 questionnaire did not include questions regarding type of CS.

Limitations

Our study is limited by the small absolute number of stillbirths after CS. To increase sample size and provide meaningful CI, we pooled datasets from GMHS 2007 and 2017. Doing so, however, creates a reference population that is harder to interpret, as characteristics of women in Ghana might have changed over time. We assume that, although population characteristics may have changed, their effect on CS did not. Therefore, variables should have similar effects in regression analysis.

Other limitations were related to the unavailability in the GMHS questionnaires of variables important for our outcome, including timing, birth weight and gestational age of stillbirths, whether CS occurred before or after the onset of labour (which was only available in the 2017 survey) and whether women had given birth by CS previously. Stillbirths could not be classified as antepartum or intrapartum, since questionnaires did not include information about presence of fetal heart rate or skin maceration (a proxy used to estimate timing of stillbirths). Nevertheless, even when GMHS would have included questions on stillbirth's birth weight, gestational age and timing of death, data from household surveys regarding these topics are often incomplete and lack criterion or convergent validity.[22 41] Women may have not been made aware of these details by their health provider or may not recall them.[22]

Also, there is a risk of residual confounding due to collapsing of independent variables' categories.[42] Categories at risk are ethnicity and religion variables' 'other' categories, as they combine varying categories with potential dissimilar effects on having CS.

Implications and future research

DHS using the newly updated DHS-8 questionnaire, which adopts a full pregnancy history capturing data on healthcare use during pregnancy and mode of birth for all births, including stillbirths, will enable analyses similar to ours for all other countries. This may reveal the scale of hidden CS in women with SBVEND.[43] We recommend that this data be used when calculating future (inter) national CS rates to include all women regardless of birth outcome in the denominator, instead of only women with live births. Based on our findings, we would also encourage separate reporting of CS rates for live births and stillbirths to assess the appropriateness of CS use.

In addition to household surveys, facility-based studies are needed to further understand CS use in women with SBVEND. High-quality facility data collection and health-facility registers may provide information on the cause and timing of fetal death, timing of CS, use of fetal heart rate monitoring and use of labour augmentation with oxytocin. Also, by using facility registries, women do not have to recount the experience of losing a child in great detail, as this may aggravate their fear, pain and grief.[44] Strengthening of facility-based data collection and documentation, and performing perinatal death reviews in women with CS may improve CS usage by enhancing professional learning and increasing accountability.

To reduce the number of unnecessary CS in women with stillbirths, in addition to deepening our understanding of explanatory factors through facility-based and community-based studies, we urge clinicians to consider alternative options for birth, such as induction of labour and assisted vaginal birth. Based on our findings, performance of CS in women from Northern regions with presumed limited access to care, but also in women with a high socioeconomic status requires particular scrutiny for being well indicated and performed in a timely manner. Electronic fetal heart rate monitoring may aid the clinician in such timely use.[45] If fetal death occurs, we advocate for the use of national, or, where these are unavailable, international guidelines in its management before, during and after birth.[46]

CONCLUSION

Analysis of a pooled sample from GMHS 2007 and 2017 showed a CS rate of 19.3% in women in Ghana with

SBVEND, double the rate in women with live births who survived the first day of life. These CS rates are currently excluded from CS rate calculations and inclusion might lead to an increase of facility-based, national and global CS rates. Future stillbirth data from household surveys and facility-based studies may reveal the exact scale of CS use in women with stillbirth and increase our understanding of why and when the decision for surgery is made. With these insights, unnecessary CS may be prevented and, instead, CS can be used for the right reasons at the right time.

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Acknowledgements We are grateful to all participating women in this study and all staff members working during GMHS 2007 and 2017. We wish to acknowledge the assistance of Tom Smekens, statistician at the Institute of Tropical Medicine in Antwerp while drafting the methodology and performing data analysis.

Contributors SZ drafted the study protocol, receiving feedback from all coauthors. AC and LB provided input on methodology, data analysis and kept record of progress. TKB provided critical interpretation of results in the context of Ghana. All authors were involved in drafting the manuscript and approved the final draft for submission. SZ serves as the guarantor and accepts full responsibility for the finished work and/or the conduct of the study, had access to the data, and controlled the decision to publish.

Funding SZ received a grand for this project from the Foundation 'De Drie Lichten' in The Netherlands. The other authors have not declared a specific grant for this research from any funding agency in the public, commercial or not-for-profit sectors. AC is funded by the Research Foundation—Flanders (FWO) for a postdoctoral fellowship (number 1294322N).

Competing interests None declared.

Patient and public involvement Patients and/or the public were not involved in the design, or conduct, or reporting, or dissemination plans of this research.

Patient consent for publication Not applicable.

Ethics approval Authorisation to access the publicly available GMHS datasets was granted by the DHS programme after registration of the study. Procedures and questionnaires for DHS surveys have been reviewed by the Inner City Fund Institutional Review Board for compliance with US legislation, while the Ghana Health Service Ethical Review Committee ensured compliance with Ghanian legislation. All questionnaires from 2007 and 2017 included a consent statement introducing the aim of the survey and voluntary participation. Verbal consent was gained by the interviewer prior to participation in both surveys.

Provenance and peer review Not commissioned; externally peer reviewed.

Data availability statement Data are available in a public, open access repository. Data are available at the DHS programme (see https://dhsprogram.com/). Authorisation to access the publicly available GMHS datasets has to be granted by the DHS programme after registration.

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REFERENCES

1 Hug L, You D, Blencowe H, *et al*. Global, regional, and national estimates and trends in stillbirths from 2000 to 2019: a systematic assessment. *Lancet* 2021;398:772–85.
2 World Health Organization. Health topics: Stillbirth. 2023. Available: https://www.who.int/health-topics/stillbirth#tab=tab_1
3 Yakoob MY, Ali MA, Ali MU, *et al*. The effect of providing skilled birth attendance and emergency obstetric care in preventing stillbirths. *BMC Public Health* 2011;11.
4 Zethof S, Christou A, Benova L, *et al*. Too much, too late: data on stillbirths to improve interpretation of Caesarean section rates. *Bull World Health Organ* 2022;100:289–91.
5 Sobhy S, Arroyo-Manzano D, Murugesu N, *et al*. Maternal and perinatal mortality and complications associated with Caesarean section in low-income and middle-income countries: a systematic review and meta-analysis. *Lancet* 2019;393:1973–82.
6 Akuze J, Cousens S, Lawn JE, *et al*. Four decades of measuring stillbirths and neonatal deaths in demographic and health surveys: historical review. *Popul Health Metr* 2021;19:8.
7 Maaløe N, Housseine N, Bygbjerg IC, *et al*. Stillbirths and quality of care during labour at the low resource referral hospital of Zanzibar: a case-control study. *BMC Pregnancy Childbirth* 2016;16:351:351.:.
8 Geelhoed D, Stokx J, Mariano X, *et al*. Risk factors for stillbirths in Tete, Mozambique. *Int J Gynaecol Obstet* 2015;130:148–52.
9 McClure EM, Saleem S, Goudar SS, *et al*. Stillbirth rates in low-middle income countries 2010 - 2013: a population-based, multi-country study from the global network. *Reprod Health* 2015;12.
10 Di Stefano L, Bottecchia M, Yargawa J, *et al*. Stillbirth maternity care measurement and associated factors in population-based surveys: EN-INDEPTH study. *Popul Health Metr* 2021;19:11.
11 Betran AP, Torloni MR, Zhang JJ, *et al*. WHO statement on Caesarean section rates. *BJOG* 2016;123:667–70.
12 Li Z, Kong Y, Chen S, *et al*. Independent and cumulative effects of risk factors associated with stillbirths in 50 Low- and middle-income countries: A multi-country cross-sectional study. *EClinicalMedicine* 2022;54:101706.
13 Bobo FT, Asante A, Woldie M, *et al*. Spatial patterns and inequalities in skilled birth attendance and Caesarean delivery in sub-Saharan Africa. *BMJ Glob Health* 2021;6:e007074.
14 Ghana Statistical Service. *Ghana maternal health survey 2007*. Calverton, Maryland, USA: GSS, GHS, and Macro International, 2009.
15 Ghana Statistical Service (GSS), Ghana Health Service (GHS), and ICF. *Ghana maternal health survey 2017*. Accra, Ghana: GSS, GHS, and ICF, 2018.
16 Christou A, Dibley MJ, Raynes-Greenow C. Beyond counting stillbirths to understanding their determinants in Low- and middle-income countries: a systematic assessment of Stillbirth data availability in household surveys. *Trop Med Int Health* 2017;22:294–311.
17 von Elm E, Altman DG, Egger M, *et al*. The strengthening the reporting of observational studies in epidemiology (STROBE) statement: guidelines for reporting observational studies. *J Clin Epidemiol* 2008;61:344–9.
18 The DHS. Data from: Ghana 2007 maternal health survey. In: *The DHS program survey datasets*. 2009. Available: https://dhsprogram.com/methodology/survey/survey-display-325.cfm
19 The DHS. Data from: Ghana 2017 maternal health survey. In: *The DHS program survey datasets*. 2018. Available: https://dhsprogram.com/methodology/survey/survey-display-506.cfm
20 Fauveau V. New indicator of quality of emergency obstetric and newborn care. *Lancet* 2007;370:1310.
21 Liu L, Kalter HD, Chu Y, *et al*. Understanding Misclassification between neonatal deaths and stillbirths: empirical evidence from Malawi. *PLoS ONE* 2016;11:e0168743.
22 the Every Newborn-INDEPTH Study Collaborative Group, Blencowe H, Bottecchia M, *et al*. Stillbirth outcome capture and classification in population-based surveys: EN-INDEPTH study. *Popul Health Metrics* 2021;19.
23 Afulani PA. Determinants of stillbirths in Ghana: does quality of Antenatal care matter *BMC Pregnancy Childbirth* 2016;16:132.
24 Ahinkorah BO, Seidu A-A, Ameyaw EK, *et al*. Beyond counting induced abortions, Miscarriages and stillbirths to understanding their risk factors: analysis of the 2017 Ghana maternal health survey. *BMC Pregnancy Childbirth* 2021;21:140.
25 Apanga PA, Awoonor-Williams JK. Predictors of Caesarean section in northern Ghana: a case-control study. *Pan Afr Med J* 2018;29:20.

26 Manyeh AK, Amu A, Akpakli DE, *et al*. Socioeconomic and demographic factors associated with Caesarean section delivery in Southern Ghana: evidence from INDEPTH network member site. *BMC Pregnancy Childbirth* 2018;18:405.
27 Banchani E, Tenkorang EY. Risk factors for Caesarean sections in Ghana: evidence from the Ghana maternal health survey. *J Biosoc Sci* 2022;54:21–38.
28 Yaya S, Uthman OA, Amouzou A, *et al*. Disparities in Caesarean section prevalence and determinants across sub-Saharan Africa countries. *Glob Health Res Policy* 2018;3:19.
29 Green SB. How many subjects does it take to do A regression analysis. *Multivariate Behav Res* 1991;26:499–510.
30 Khan MN, Kabir MA, Shariff AA, *et al*. n.d. Too many yet too few Caesarean section deliveries in Bangladesh: evidence from Bangladesh demographic and health surveys data. *PLOS Glob Public Health*;2:e0000091.
31 Afulani PA. Rural/urban and socioeconomic differentials in quality of Antenatal care in Ghana. *PLoS One* 2015;10:e0117996.
32 The World Bank Group. Female population in Ghana. World development indicators. 2019. Available: https://data.worldbank.org/indicator/SP.POP.TOTL.FE.IN?locations=GH
33 Murad H, Fleischman A, Sadetzki S, *et al*. Small samples and ordered logistic regression: does it help to collapse categories of outcome. *Am Stat* 2003;57:155–60.
34 Heinze G, Dunkler D. Five myths about variable selection. *Transpl Int* 2017;30:6–10.
35 Peduzzi P, Concato J, Kemper E, *et al*. A simulation study of the number of events per variable in logistic regression analysis. *J Clin Epidemiol* 1996;49:1373–9.
36 Haruna A. Change and cultural survival in Dagbon: assessing the influence of Islam on aspects of Dagbamba cultural practices. *IJIRAS* 2015;2:28–37.
37 Ameyaw EK, Amoah RM, Njue C, *et al*. An assessment of hospital maternal health services in northern Ghana: a cross-sectional survey. *BMC Health Serv Res* 2020;20:1088.
38 Aftab S, Ali N, Saleh F, *et al*. Indications of primary cesarean section in Multipara. *J Bahria Univ Med Dent Coll* 2019;09:105–8.
39 Okyere J, Duah HO, Seidu A-A, *et al*. Inequalities in prevalence of birth by Caesarean section in Ghana from 1998-2014. *BMC Pregnancy Childbirth* 2022;22:64.
40 Miller S, Abalos E, Chamillard M, *et al*. Beyond too little, too late and too much, too soon: a pathway towards evidence-based, respectful maternity care worldwide. *Lancet* 2016;388:2176–92.
41 Benova L, Moller A-B, Hill K, *et al*. What is meant by validity in maternal and newborn health measurement? A conceptual framework for understanding indicator validation. *PLoS One* 2020;15:e0233969.
42 Lash TL. Collapsing high-end categories of Comorbidity may yield misleading results. *Clin Epidemiol* 2009;1:11–5.
43 The DHS program. DHS model questionnaire – phase 8 (English, French). 2020. Available: https://dhsprogram.com/publications/publication-dhsq8-dhs-questionnaires-and-manuals.cfm
44 Kwesiga D, Tawiah C, Imam MA, *et al*. Barriers and Enablers to reporting pregnancy and adverse pregnancy outcomes in population-based surveys: EN-INDEPTH study. *Popul Health Metr* 2021;19:15.
45 Kamala BA, Ersdal HL, Dalen I, *et al*. Implementation of a novel continuous fetal Doppler (Moyo) improves quality of Intrapartum fetal heart rate monitoring in a resource-limited tertiary hospital in Tanzania: an observational study. *PLoS One* 2018;13:e0205698.
46 Royal College of Obsetricians & Gynaecologists. Green-top guideline No.55: late Intrauterine fetal death and Stillbirth. *RCOG* 2018. Available: https://www.rcog.org.uk/guidance/browse-all-guidance/green-top-guidelines/late-intrauterine-fetal-death-and-stillbirth-green-top-guideline-no-55