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Understanding the Continuum of Maternal Morbidity in Accra, Ghana

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Abstract The objective was to determine the levels of maternal morbidity from no complications to near miss and describe factors associated with different levels of morbidity. We conducted an observational study of all women delivering at a tertiary hospital in Accra, Ghana between October 2010 and March 2011. We examined the factors associated with the continuum of maternal outcomes in terms of severity using multinomial logistic regression. Data were extracted from women's maternal care files with the main outcome measures of no complications, non-life threatening complications, potentially life-threatening conditions (PLTC), and near miss as defined by World Health Organization. Our study includes 1,586 women with no complications, 1,205 women with non-life threatening complications, 516 women with PLTC, and 94 near-miss cases. All of the factors associated with PLTC and near-miss cases were similar. None of the socio-demographic variables remained significant in the multivariate analysis comparing different levels of severe morbidity with no complications. Women with no complications shared similar characteristics with women who experienced non-life threatening complications. As compared to women who had no complications, women who had severe morbidity were significantly more likely to have had no antenatal care. Our results underline the concept that morbidity is a continuum and indicate that if the underlying causes of poor maternal health outcomes are addressed, it is likely that changes such as better access to antenatal care will improve health outcomes across the continuum of morbidity. However, by only monitoring near-miss cases and mortality, we underestimate the impact on women who will live with non-life threatening, yet serious maternal morbidities.

Keywords Near miss · Potentially life-threatening conditions · Severe maternal morbidity · Measurement · Ghana · Sub-Saharan Africa

Abbreviations

ANC	Antenatal care
CI	Confidence interval
PLTC	Potentially life-threatening conditions
RRR	Relative risk ratio
WHO	World Health Organization

Introduction

Confidential inquiries into maternal mortality have been in place in countries like United Kingdom since 1950s; however, as the maternal mortality ratios have continued to decline, inquiries into severe maternal morbidity have commenced [1]. The concept of severe acute maternal morbidity or "near miss" was introduced to investigate deficiencies in maternal care as a complementary measure

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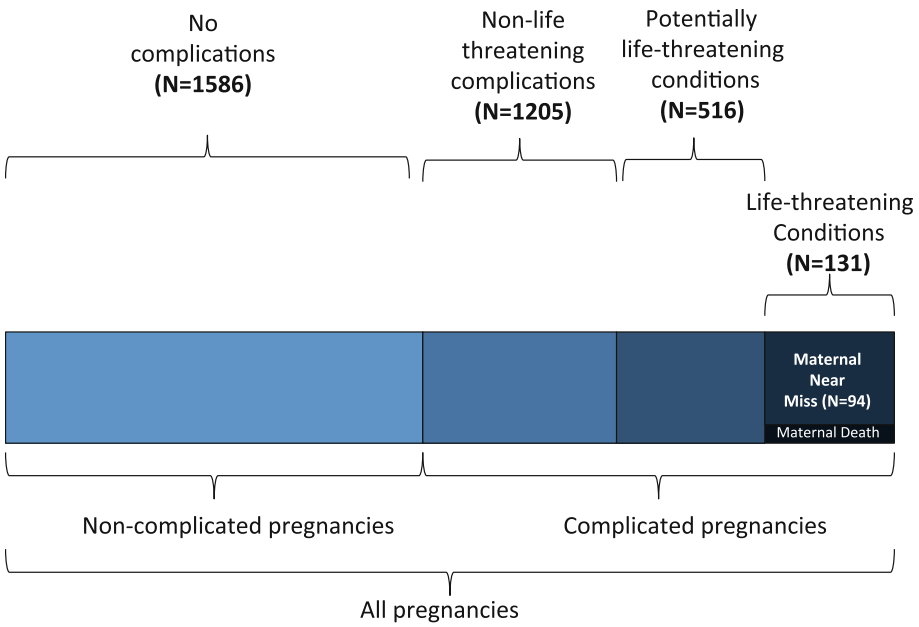

Fig. 1 The spectrum of maternal morbidity: from non-complicated pregnancies to near miss and maternal death including the number of women in each category among the study population [11]

to maternal deaths [2–4]. It first had two definitions: (a) a mishap that may or may not have had a poor outcome, or (b) a life-threatening episode where substandard care may or may not be identified [1]. Over time the definition of near miss has evolved, but many researchers developed and adapted their own definitions, leading to problems in comparing outcomes and rates over time and across settings.

Recently, there have been three major approaches to the identification of near-miss cases: (1) Clinical criteria related to a specific disease entity (i.e., preeclampsia, postpartum hemorrhage) [5], (2) Intervention-based criteria (i.e., admission to ICU, need for a blood transfusion) [1, 3, 6, 7], or (3) Organ system dysfunction-based criteria [8]. Depending on the approach, the prevalence of near miss varies. In a recent systematic review, prevalence rates of near miss are between 0.6 and 14.98 % for disease-specific criteria, between 0.04 and 4.54 % for management-based criteria and between 0.14 and 0.92 % for organ-based dysfunction, better known as Mantel criteria. These rates are higher in low-income and middle-income countries of Africa and Asia [9]. However, due to wide variation in identification of cases as well as the variation within each category, it had not been possible to pool the data and make a summary estimate for near-miss rates globally [9, 10].

In 2009, a WHO Working Group defined maternal near-miss morbidity as *"a woman who nearly died but survived a complication that occurred during pregnancy, childbirth or within 42 days of termination of pregnancy"* [11]. Figure 1 shows the spectrum of maternal morbidity, from non-complicated pregnancies to maternal death. At the end of this spectrum, a woman with a life-threatening condition will either become a maternal near-miss case or a maternal death [11]. The criteria for identifying a maternal near miss are described in Table 1 and are defined by organ system and include clinical criteria, laboratory markers, and management-based proxies [8, 11]. These criteria have been tested and validated as being able to provide robust and reliable data and theoretically the set of near-miss criteria can be used at any level of facility [11, 12]. In a recently published multi-country survey on severe maternal morbidity, the frequency of near miss ranges between 3.9 and 25.3 % in participating institutions from sub-Saharan Africa and between 2.6 and 16.7 % in Asia [13].

Our study aims (1) to determine the prevalence of maternal morbidity according to the following categories [no complications, non-life threatening complications, potentially life-threatening conditions (PLTC) and near miss] and (2) to analyze the relationships between potential maternal risk factors and the levels of maternal morbidity along this continuum, based on data collected from over 3,000 women in a tertiary hospital in Accra, Ghana.

Maternal Health in Ghana

Despite the slow progress, maternal health in Ghana has improved over the past two decades. According to the latest estimations, between 1990 and 2010, maternal mortality ratio fell from 740 per 100,000 live births to 350 per 100, 000 live births [14]. The latest Demographic Health Survey (DHS) shows that over nine in ten mothers received at least one antenatal care visit from a health professional and nationally, 57 % of births occurred in health facilities, and 59 % were assisted by skilled health care providers [15]. Recently, Ghana initiated an action plan under Millennium Development Goal (MDG) Acceleration Framework,

Table 1 Criteria to identify maternal near miss in the study population [17]

Dysfunctional system	Clinical criteria	Laboratory markers	Management based proxies
Cardiovascular	Shock	pH < 7.1	Use of continuous vasoactive drugs
	Cardiovascular arrest	Lactate > 5	Cardio-pulmonary resuscitation
Respiratory	Acute cyanosis	Oxygen saturation <90 % for ≥ 60 min	Intubation and ventilation not related to anesthesia
	Gasping	PaO2/FiO2 < 200 mmHg	
	Respiratory rate > 40 or > 6 bpm		
Renal	Oliguria non responsive to fluids or diuretics	Creatinine ≥ 300 μmol/l or ≥3.5 mg/dL	Dialysis for acute renal failure
Hematologic/ Coagulation	Failure to form clots	Acute severe thrombocytopenia (< 50,000 platelets)	Transfusion of ≥5 units of blood/ red cells
Hepatic	Jaundice in the presence of preeclampsia	Bilirubin > 100 μmol/l or >6.0 mg/dL	
Neurologic	Any loss of consciousness not medically induced, lasting > 6 h		
	Stroke		
	Uncontrollable fit/status epilepticus		
	Total paralysis		
Alternative severity proxy			Hysterectomy following infection or hemorrhage

highlighting the need to focus efforts on skilled delivery, emergency obstetric and neonatal care and family planning [16].

Methods

Study Population

The data collection was prospective and took place at an urban tertiary referral center with approximately 10,000 deliveries annually. Data were collected between October 2010 and March 2011. The region where the hospital is located has the highest levels of facility deliveries (83 %) in Ghana, and the study facility serves a population of approximately three million [15].

The study population included all women who delivered at the facility during the study period. The WHO maternal near-miss surveillance and assessment tool was used to collect data [17]. Information on demographic characteristics, maternal/perinatal information, process indicators and near-miss screening were abstracted from patient files every day at the maternity wards and twice a week at the gynecology ward. All of the variables and outcomes used in our analyses were collected from the patient files. More detailed information on our methodology can be found elsewhere [18].

The study protocol was reviewed and approved by University of Ghana Medical School College of Health Sciences (Protocol # MS-Et/M.2-P.4.6/2010-11) on October 7th, 2010 and Johns Hopkins School of Public Health Institutional Review Board (Protocol #2719) on October 11th, 2010. As there was no direct contact with patients, individual consent forms from women were not required for the quantitative part of the study.

Variables

The outcomes in our study were different levels of morbidity in terms of severity—no complications, non-life threatening complications, PLTC and near miss. If a woman had no known complications related to pregnancy, childbirth, postpartum period or abortion, then she was identified as "no complications". Identifying potential near-miss cases was a two-step process. First, women with "potentially life-threatening conditions" (PLTC) were identified, based on whether they had any severe complication (severe post-partum hemorrhage, severe preeclampsia, eclampsia, sepsis or severe systemic infection, ruptured uterus). Moreover, it was recorded if they had received blood products, had a laparotomy-excluding C-section, were admitted to the ICU or spent more than 6 h in the recovery room. Second, near-miss cases were further identified by organ system dysfunction using markers on clinical criteria, laboratory markers and management-based proxies (Table 1). The women who had a known complication in their file, but the complication was not identified as a potentially life-threatening or a near miss by the above criteria, were coded as "non-life threatening complications". The data collection

tool used in this study can be found as a supplemental file (Supplemental File 1).

We selected known variables associated with adverse maternal outcomes (i.e., age, number of pregnancies, and antenatal visit), as well as proxies of socio-economic status (i.e., marital status, religion, and education) a priori. The dataset included variables on gestational age, final mode of delivery and access to the facility, in terms of being a referral and delivering or operated on within 3 h of hospital arrival. We excluded these variables from our modeling, as they are, themselves, proxies for severity of maternal outcomes.

Data Analysis

Exploratory data analysis was conducted to examine the data for frequencies, distributions, and missing data. Our outcome was the severity of morbidity, where we created mutually exclusive groups (no complications, non-life threatening complications, PLTC, and near miss). Due to the categorical nature of our outcome variable, we used multinomial logistic regression models, both for the bivariate and multivariate analyses. This model expresses the log probabilities of each comparison category (non-life threatening complications, PLTC or near miss) relative to the reference category (no complications) as a different function of the independent variables included in the study. The results in the multinomial logistic regression models are reported as relative risk ratios (RRR).

First, we conducted bivariate analyses to examine the unadjusted associations between the outcome and two groups of variables: (1) socio-demographic characteristics (age, marital status, religion, and education) and (2) obstetric-related characteristics (number of pregnancies, and antenatal care visits). For the multivariate analysis, we examined factors associated with the continuum of maternal outcomes. We first adjusted the models with socio-demographic characteristics, and then added obstetric-related characteristics. We used no complications as the comparison category for the main analysis but also provide p-values for the comparison of potentially life-threatening versus near miss in Tables 3 and 4. This comparison was selected as it was another category introduced along with the WHO near-miss identification criteria [17]. In all analyses, the cut-off for statistical significance was $p < 0.05$. Stata Release 12 was used for the statistical analyses [19].

Results

Study Population

During the 21-week data collection period, there were 3,206 live births, 328 stillbirths resulting in 1,205 women with non-life threatening complications, 516 women with PLTC, 94 near miss cases and 37 maternal deaths. Overall our dataset consisted of 3,438 women and 3,379 deliveries. In our study population, 2,188 patients (64.4 %) were referred to the facility, whereas the rest were patients followed up by the study facility.

The socio-demographic, obstetric and current pregnancy variables by level of morbidity for the total study population are presented in Table 2. A majority of our population was between 20 and 34 years of age (74.5 %), married (84 %), Christian (86 %) and with secondary or higher level education (68.6 %). Three out of four women had more than one pregnancy in their lifetime and one in five had a previous C-section. Related to their current pregnancy, a majority of the women had at least one antenatal care visit (89 %), two-thirds delivered between 38 and 40 weeks and 33 % had a C-section. Stillbirths became more common as the severity of the morbidity increased.

Bivariate Analysis

Table 3 shows the results of the unadjusted multinomial logistic regression analysis. In this analysis we compared women with no complications to those with non-life threatening complications, PLTC and near miss. Moreover, we compared maternal near-miss cases to PLTC. The socio-demographic factors showed no statistically significant associations with non-life threatening complications or PLTC. Compared to the women with no complications, women who experienced a near miss were less likely to be Muslim (RRR = 0.40, 95 % CI [0.16–0.98], $p < 0.05$).

The obstetric-related variables included number of pregnancies and antenatal care visits. As compared with women who had no complications, women with PLTC were pregnant for the first time or had more than three pregnancies. Antenatal care was significantly associated with morbidity. As compared to women who had no complications, women with no antenatal care were significantly more likely to experience a potentially life-threatening condition (RRR = 4.51, 95 % CI [3.38–6.03], $p < 0.001$) or a near miss (RRR = 4.59, 95 % CI [2.70–7.81], $p < 0.001$). This association was also significant for PLTC among women who had 1–3 antenatal care visits (RRR = 1.37, 95 % CI [1.03–1.82], $p < 0.05$).

Compared to women with no complications, all other groups in our sample were more likely to have undergone a surgical procedure including a C-section or laparotomy for ectopic pregnancy (data not shown). Women with any complications were significantly more likely to be referral cases compared to women with no complications. There seems to be a dose–response relationship between the severity of the morbidity and referral status as the association became stronger with the increase in the severity of

Table 2 Background characteristics of the study population by maternal health outcomes, Accra, Ghana

	No complications n (%) (n = 1,586)	Non-life threatening complications n (%) (n = 1,205)	Potentially life-threatening conditions n (%) (n = 516)	Maternal Near Miss n (%) (n = 94)	Total Population n (%) (n = 3,438)	Pearson χ^2 p value
Socio-demographic characteristics						
Age						
< 20	116 (7.3)	96 (8.0)	26 (5.0)	2 (2.1)	240 (7.0)	0.013
20–34	1,183 (74.6)	907 (75.3)	375 (72.7)	69 (73.4)	2,562 (74.5)	
>=35	287 (18.1)	202 (16.7)	115 (22.3)	23 (24.5)	636 (18.5)	
Marital status						
Married/ Cohabitation	1,348 (85.0)	1,020 (84.7)	429 (83.1)	83 (88.3)	2,886 (84.0)	0.555
Single/ Divorced/ Separated	216 (13.6)	162 (13.5)	77 (15.0)	9 (9.6)	466 (13.5)	
Missing	22 (1.4)	22 (1.8)	10 (1.9)	2 (2.1)	85 (2.5)	
Religion						
Christian	1,376 (86.8)	1,038 (86.1)	449 (87.0)	88 (94.6)	2,958 (86.0)	0.186
Muslim	194 (12.2)	153 (12.7)	58 (11.2)	5 (5.4)	413 (12.0)	
Missing	16 (1.0)	14 (1.2)	9 (1.7)	0 (0.0)	67 (2.0)	
Tribe						
Aka	713 (45.0)	548 (45.5)	242 (46.9)	54 (57.4)	1,561 (45.4)	0.086
Ga	354 (22.3)	230 (19.1)	96 (18.6)	17 (18.1)	699 (20.3)	
Ewe	228 (14.4)	179 (14.8)	71 (13.8)	16 (17.0)	495 (14.4)	
Other	248 (15.6)	208 (17.3)	80 (15.5)	6 (6.4)	545 (15.9)	
Missing	43 (2.7)	40 (3.3)	27 (5.2)	1 (1.1)	138 (4.0)	
Education						
None	127 (8.0)	80 (6.6)	44 (8.53)	8 (8.5)	259 (7.5)	0.345
Primary (0–6 years)	176 (11.1)	146 (12.1)	54 (10.5)	7 (7.5)	383 (11.1)	
Secondary or more (7 + years)	1,148 (72.4)	842 (69.9)	307 (59.5)	60 (63.8)	2,360 (68.6)	
Missing	135 (8.5)	137 (11.4)	111 (21.5)	19 (20.2)	436 (12.7)	
Obstetric history						
Number of pregnancies						
One pregnancy	374 (23.6)	356 (29.5)	139 (26.9)	15 (16.0)	887 (25.8)	<0.001
2–3 pregnancies	728 (45.9)	555 (46.1)	189 (36.6)	40 (42.5)	1,516 (44.1)	
> 3 pregnancies	484 (30.5)	294 (24.4)	188 (36.5)	39 (41.5)	1,035 (30.1)	
Number of previous C-section						
No previous c-section	1,275 (80.4)	1,030 (85.5)	428 (83.0)	77(81.9)	2,835 (82.5)	0.001
One previous C-section	277 (17.5)	165 (13.7)	66 (12.8)	13 (13.8)	523 (15.2)	
≥ 2 previous C-sections	30 (1.9)	9 (0.7)	13 (2.5)	3 (3.2)	56 (1.6)	
Missing	4 (0.2)	1 (0.1)	9 (1.7)	1 (1.1)	24 (0.7)	
Current pregnancy						
Gestational age						

Table 2 continued

	No complications n (%) (n = 1,586)	Non-life threatening complications n (%) (n = 1,205)	Potentially life-threatening conditions n (%) (n = 516)	Maternal Near Miss n (%) (n = 94)	Total Population n (%) (n = 3,438)	Pearson χ^2 p value
≤ 25 weeks	15 (0.9)	58 (4.8)	36 (7.0)	2 (2.1)	122 (3.5)	0.001
25–30 weeks	36 (2.3)	41 (3.4)	34 (6.6)	10 (10.6)	124 (3.6)	
31–37 weeks	186 (11.7)	193 (16.0)	140 (27.1)	30 (31.9)	554 (16.1)	
38–40 weeks	1,146 (72.3)	738 (61.2)	196 (38.0)	21 (22.3)	2,102 (61.1)	
41–45 weeks	134 (8.5)	118 (9.8)	22 (4.3)	6 (6.4)	280 (8.1)	
Missing	69 (4.3)	57 (4.7)	88 (17.1)	25 (26.6)	256 (7.4)	
Antenatal care						
No visits	106 (6.7)	99 (8.2)	119 (23.1)	22 (23.4)	346 (10.1)	<0.001
1–3 visits	232 (14.6)	177 (14.7)	79 (15.3)	16 (17.02)	504 (14.7)	
4+ visits	1,238 (78.1)	920 (76.4)	308 (59.7)	56 (59.6)	2,525 (73.4)	
Missing	10 (0.6)	9 (0.7)	10 (1.9)	0 (0.0)	63 (1.8)	
Proportion of C-sections	403 (25.4)	425 (35.4)	254 (49.6)	42 (46.2)	1,124 (33.2)	<0.001
Stillbirths	8 (0.5)	137 (11.4)	115 (22.3)	42 (44.7)	328 (9.5)	<0.001

the condition from the non-life threatening complications to near miss (non-life threatening complications: RRR = 1.30, 95 % CI [1.11–1.52], $p < 0.001$; PLTC: RRR = 1.79, 95 % CI [1.44–2.22], $p < 0.001$; near miss: RRR = 2.07, 95 % CI [1.28–3.35], $p < 0.01$)).

There were no significant differences between having a potentially life-threatening condition and a near miss except that the nulliparous women were less likely to experience a near miss compared to women with PLTC (RRR = 0.51, 95 % CI [0.27–0.96], $p < 0.05$).

Multivariate Analysis

A multivariate model was constructed to compare women with no complications to women who experienced a non-life threatening complication, a potentially life-threatening condition or a near miss (Table 4). Model 1, which includes the socio-demographic factors modeled simultaneously, shows that younger maternal age (<20) remained significantly associated with PLTC. Model 2, which includes the pregnancy-related factors in addition to socio-demographics, shows that women with only one pregnancy are more likely to experience some form of complication, but not a near miss. Furthermore, the association between antenatal care visits and severe morbidity persisted, where women experiencing a potentially life-threatening condition or a near miss were more likely to have no experience of antenatal care. It should also be noted that women with no complications shared similar characteristics with women who experienced non-life threatening complications.

In order to further explore the relationship between PLTC and maternal near miss, we ran the model using PLTC group as the base outcome instead of no complications and found that none of the variables used in our final model differed between these two groups of severe morbidity.

Discussion

In our study, all of the factors associated with PLTC and near-miss cases were similar. None of the socio-demographic variables remained significant in the multivariate analysis between different levels of severe morbidity. Women with no complications shared similar characteristics with women who experienced non-life threatening complications. As compared to women who had no complications, women who had severe morbidity were significantly more likely to have had no antenatal care. In part, the lack of statistical significance may be due to small sample sizes in some of the categories and comparisons.

The results from our analyses suggest that women who experienced a near miss shared many characteristics with women who had a potentially life-threatening condition, underlining the concept that morbidity is a continuum. These results suggest that near miss, as well as PLTC, should be included in the analysis of severe morbidity to identify deficiencies in care in order to improve maternal health in the facilities.

These results also highlight the importance of the health care system organization in terms of access to and

Table 3 Unadjusted multinomial logistic regression of socio-demographic and obstetric related variables on maternal outcomes, relative risk ratios (RRR) and 95 % Confidence Intervals (95 % CIs)

	Non-life threatening complications RRR (95 % CI) (n = 1,205)	Potentially life-threatening conditions RRR (95 % CI) (n = 516)	Maternal Near Miss RRR (95 % CI) (n = 94)
Maternal socio-demographic characteristics			
Age			
< 20	1.08 (0.81–1.43)	0.71 (0.45–1.10)	0.30 (0.07–1.22)
20–34	1.0	1.0	1.0
>=35	0.92 (0.75–1.12)†	1.26 (0.99–1.62)	1.37 (0.84–2.24)
Marital Status			
Married/ Cohabitating	1.0	1.0	1.0
Single/Divorced	0.99 (0.79–1.23)	1.12 (0.84–1.48)	0.68 (0.34–1.37)
Religion			
Christian	1.0	1.0	1.0
Muslim	1.05 (0.83–1.31)	0.91 (0.67–1.25)	0.40* (0.16–0.98)
Education			
None	0.86 (0.64–1.15)†	1.29 (0.90–1.87)	1.21 (0.56–2.58)
Primary	1.13 (0.89–1.43)	1.15 (0.82–1.59)	0.76 (0.34–1.69)
Secondary or more	1.0	1.0	1.0
Obstetric related			
Number of pregnancies			
One pregnancy	1.25* (1.04–1.50)	1.43** (1.11–1.84)	0.73 (0.40–1.34)†
2–3 pregnancies	1.0	1.0	1.0
> 3 pregnancies	0.80* (0.66–0.96)†††	1.50** (1.19–1.89)	1.47 (0.93–2.31)
Antenatal care			
No visits	1.26 (0.94–1.67)†††	4.51*** (3.38–6.03)	4.59*** (2.70–7.81)
1–3 visits	1.03 (0.83–1.27)	1.37* (1.03–1.82)	1.52 (0.86–2.70)
4 + visits	1.0	1.0	1.0

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ (comparison is no complications)

† $p < 0.05$; †† $p < 0.01$; ††† $p < 0.001$ (comparison is potentially life-threatening conditions)

attendance at antenatal care [20, 21] and indicate that if the underlying causes of poor maternal health outcomes are addressed, it is likely that these changes will positively impact health outcomes across the continuum of maternal health. Our study clearly suggests that women who had four or more antenatal care visits also were less likely to experience severe maternal morbidity. While we cannot rule out reverse causality, the antenatal care visits might be identifying high-risk cases and preventing the complications to lead to severe morbidity.

In this study, we have used a tool based on WHO near-miss criteria. The WHO near-miss criteria and the tool are designed for use in facilities and cannot be used in community-based studies, where women themselves report on the complications, as they depend on the existence of functioning laboratories and basic critical care monitoring available in the facilities [11]. Therefore it is advantageous to have all different types of criteria in terms of clinical, lab and management based proxies. In a validation study conducted in Brazil, management-based proxies identified 94 % of the cases where none of the other markers were observed and it was also found to be very valuable as they potentially indicated where intervention occurred early enough to prevent organ failure and potential maternal death [12].

In terms of limitations, it should be noted that even at a teaching facility, during the formative research, we identified that most of the laboratory markers were not available in a timely manner or routinely collected to aid the identification of the near-miss cases. Therefore, cases were mainly identified by the clinical criteria or management-based proxies. Considering this and the continuous nature of the maternal morbidity, some of the maternal near-miss cases might be misclassified and therefore underreported. Furthermore it raises the question whether the available lab facilities are being utilized effectively in terms of influencing the timely decision-making in critical patient management at the facilities. Further research should focus on the implementation of the identification criteria and the interpretation of the results in different levels of facilities in low- and middle-income countries based on the availability of these markers [18, 22, 23]. Another limitation is that we had small number of maternal deaths and relatively small number of near-miss cases limiting our ability to

Table 4 Multivariate multinomial logistic regression models of severe maternal morbidity outcomes, adjusted relative risk ratios (RRR) and 95 % Confidence Intervals (95 % CIs)

	Model 1 RRR (95 % CI)			Model 2 RRR (95 % CI)		
	Non-life threatening complications	Potentially life-threatening conditions	Near miss	Non-life threatening complications	Potentially life-threatening conditions	Near miss
Age						
<20	1.06 (0.76-1.47)††	0.41** (0.22–0.77)	0.41 (0.09–1.82)	0.88 (0.62–1.24)††	0.31*** (0.17–0.59)	0.38 (0.08–1.77)
20–34	1.00	1.00	1.00	1.00	1.00	1.00
> = 35	0.89 (0.72–1.11)†	1.2 (0.91–1.58)	1.43 (0.83–2.47)	1.06 (0.84–1.34)	1.23 (0.91–1.67)	1.25 (0.69–2.25)
Marital Status						
Married/ Cohabitating	1.00	1.00	1.00	1.00	1.00	1.00
Single/Divorced	0.93 (0.72–1.19)	1.10 (0.77–1.56)	0.92 (0.42–2.02)	0.85 (0.66–1.10)	1.00 (0.70–1.43)	0.90 (0.41–1.99)
Religion						
Christian	1.00	1.00	1.00	1.00	1.00	1.00
Muslim	0.99 (0.77–1.29)	0.79 (0.54–1.16)	0.40 (0.14–1.14)	0.97 (0.75–1.26)	0.76 (0.52–1.12)	0.41 (0.14–1.16)
Education						
None	0.89 (0.64–1.18)	1.42 (0.97–2.09)	1.51 (0.69–3.30)	0.90 (0.66–1.24)	1.30 (0.87–1.93)	1.3 (0.59–2.89)
Primary	1.12 (0.88–1.43)	1.17 (0.83–1.66)	0.87 (0.39–1.96)	1.20 (0.94–1.54)	1.18 (0.83–1.68)	0.78 (0.35–1.77)
Secondary or more	1.00	1.00	1.00	1.00	1.00	1.00
Number of pregnancies						
One pregnancy	–	–	–	1.31* (1.07–1.61)	1.57** (1.16–2.12)	1.07 (0.54–2.12)
2–3 pregnancies	–	–	–	1.00	1.00	1.00
>3 pregnancies	–	–	–	0.76* (0.61–0.93)††	1.15 (0.86–1.52)	1.42 (0.81-2.47)
Antenatal care						
No visits	–	–	–	1.07 (0.73–1.59)†††	3.16*** (2.10–4.75)	2.57* (1.11–5.93)
1–3 visits	–	–	–	1.09 (0.86–1.37)	1.44* (1.06–1.97)	1.70 (0.93–3.13)
4 + visits	–	–	–	1.00	1.00	1.00

* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$ (comparison is no complications)

† $p < 0.05$; †† $p < 0.01$; ††† $p < 0.001$ (comparison is potentially life-threatening conditions)

examine factors related to the full continuum of maternal outcomes and under powering some comparisons, respectively. Finally, our data represent a single facility in an urban area, and may not reflect other facilities in Ghana or elsewhere in sub-Saharan Africa.

Despite limitations, we observed that with sufficient training of the clinical staff and research assistants within the facility, it was feasible to identify and collect data on maternal near-miss cases in a sub-Saharan African facility setting, in line with recent studies including the WHO Multi-Country Survey [13, 24]. The next and more challenging step at the national and international level will be to integrate these procedures as part of routine surveillance systems involving all cadres of health care professionals from nurses to obstetricians. In many of these settings, midwives also play an important role in triaging women when they come to the facility. Promising initiatives are ongoing in the field such as Brazil's national network for surveillance of severe maternal morbidity [25].

Complications of pregnancy, childbirth, and the postpartum period may lead to death or cause a continuum of morbidities that affect women's health for short or long-term periods during and after pregnancy, and even throughout their lives [26–28]. Such morbidities are also associated with poor fetal and newborn outcomes [29]. Beyond the recent developments on maternal near miss and PLTC, the lack of a common definition and identification criteria for maternal morbidity, standardized assessment

tools especially at community or primary health care level, and common indicators to measure morbidity have restricted valid, routine, and comparable measurements [30]. Therefore the efforts to standardize the definition and identification criteria are much needed in this area, however one should be cautious while defining cut-off points across the spectrum of severity given the difficulty in transforming a continuous variable into a discrete one [12, 31]. Nonetheless, accurate and routine measurements of the spectrum of maternal morbidity are necessary to inform policy and program decisions and resource allocation that will also help reducing maternal deaths, and long-term suffering and disability for women [32, 33].

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Conflict of interest None.

Ethical statement The study protocol was reviewed and approved by University of Ghana Medical School College of Health Sciences (Protocol # MS-Et/M.2-P.4.6/2010-11) on October 7th, 2010 and Johns Hopkins School of Public Health Institutional Review Board (Protocol #2719) on October 11th, 2010.

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