Epidemiology, Outcomes, and Risk Factors for Mortality in Critically Ill Women Admitted to an Obstetric High-Dependency Unit in Sierra Leone

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Abstract. A better understanding of the context-specific epidemiology, outcomes, and risk factors for death of critically ill parturients in resource-poor hospitals is needed to tackle the still alarming in-hospital maternal mortality in African countries. From October 2017 to October 2018, we performed a 1-year retrospective cohort study in a referral maternity hospital in Freetown, Sierra Leone. The primary endpoint was the association between risk factors and high-dependency unit (HDU) mortality. Five hundred twenty-three patients (median age 25 years, interquartile range [IQR]: 21–30 years) were admitted to the HDU for a median of 2 (IQR: 1–3) days. Among them, 65% were referred with a red obstetric early warning score (OEWS) code, representing 1.17 cases per HDU bed per week; 11% of patients died in HDU, mostly in the first 24 hours from admission. The factors independently associated with HDU mortality were ward rather than postoperative referrals (odds ratio [OR]: 3.21; 95% CI: 1.48–7.01; $P = 0.003$); admissions with red (high impairment of patients' vital signs) versus yellow (impairment of vital signs) or green (little or no impairment of patients' vital signs) OEWS (OR: 3.66; 95% CI: 1.15–16.96; $P = 0.04$); responsiveness to pain or unresponsiveness on the alert, voice, pain unresponsive scale (OR: 5.25; 95% CI: 2.64–10.94; $P \leq 0.0001$); and use of vasopressors (OR: 3.24; 95% CI: 1.32–7.66; $P = 0.008$). Critically ill parturients were predominantly referred with a red OEWS code and usually required intermediate care for 48 hours. Despite the provided interventions, death in the HDU was frequent, affecting one of 10 critically ill parturients. Medical admission, a red OEWS code, and a poor neurological and hemodynamic status were independently associated with mortality, whereas adequate oxygenation was associated with survival.

INTRODUCTION

Maternal mortality is globally declining but still represents a heavy burden in some regions of the world.¹ Above all countries, Sierra Leone has the primacy with the highest maternal mortality ratio with 1,360 deaths per 100,000 live births in 2015.¹ During the last decades, to reach Millennium Development Goal (MDG) number 5,² global strategies have prioritized family planning and access to care and birth with a skilled attendant.³ Intensive care interventions have lagged behind in the effort to reduce maternal mortality and morbidity. The transition from the MDGs to the Sustainable Development Goals in 2015 led to increased attention to the continuum of care for women, thus including critical care.⁴

Resource-limited settings face the highest burden of obstetric critical care, including conditions such as eclampsia, hemorrhage, coagulopathy, and sepsis.⁵ All these conditions may benefit from an increased short-term level of monitoring and care, as provided by high-dependency units (HDUs).⁶ High-dependency units are distinct organizational environments for clinical activity and care, operating in strict cooperation with other departments in the hospital.⁷ Commonly recognized aims for HDUs are the monitoring and support of threatened or failing vital functions in critically ill patients. In particular, focused interventions, such as multiparametric monitoring, accurate intravenous fluid management, rational oxygen administration, pain management, blood

transfusions, and renal output monitoring in the early postoperative period may impact outcomes for critical pregnant women in a referral comprehensive emergency obstetric care (CEmOC) service.⁸

The characteristics and needs of obstetric critically ill patients and the potential role of patient centralization and obstetric HDUs in resource-limited settings remain scarcely explored. The current study aimed to investigate the epidemiology, clinical outcomes, and risk factors for mortality of critically ill parturients admitted to an obstetric HDU in a setting with severe limitations in resources and an extreme maternal mortality.

METHODS

Study design. This is a retrospective study of women admitted to the HDU of the Princess Christian Maternity Hospital (PCMH), Freetown, Sierra Leone, from October 2, 2017 to October 2, 2018. The study protocol was approved by the Sierra Leone Ethics and Scientific Review Committee on December 18, 2018. The need for informed consent was waived. The study was registered on ClinicalTrials.gov (study identifier NCT04121234).

Study setting. With 129 beds, the PCMH is the largest maternity referral hospital in Sierra Leone with a reference population of 1.5 million inhabitants. The PCMH is primarily an obstetric institution with approximately 9,000 admissions and 6,500 deliveries per year.^{9,10} One-third of the parturients develop major obstetric emergencies, including peripartum hemorrhage, sepsis, and preeclampsia (PE).^{9,10} Operating theater facilities are essential; anesthetic service is available with a majority of spinal anesthesia procedures.

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The HDU is a 4-bed medium-care unit, with a basic model of intermediate intensive care defined on few essential criteria such as a high nurse-to-patient ratio, close monitoring of vital signs, personalized intravenous fluid and vasopressor therapy management, a rational use of oxygen, and a very basic point-of-care laboratory.¹¹ Electricity and clean water are continuously available, and oxygen is generated through bedside oxygen concentrators, with a maximal output of 10 L/minute and maximal purity of 96%. No mechanical ventilators or dialysis apparatus are available in the unit or hospital. A basic neonatal intensive care unit (ICU) is available as a separate entity.

Patients. Patients were eligible if 1) admitted to the HDU, 2) being pregnant or within 42 days after termination of pregnancy, 3) between October 2, 2017 and October 2, 2018. No exclusion criteria were used.

Study endpoints. The primary endpoint was the association between several potentially modifiable and nonmodifiable factors, as standardly collected in the patient chart of each patient, and mortality during HDU stay. The secondary endpoints were demographic characteristics, reasons of admission, obstetric early warning score (OEWS) at admission, treatments received, vital parameters on presentation, admission time (night/day or weekend/working days), length of stay (LOS) in the HDU, discharge destination, and hospital mortality.

Data collection. A set of predefined variables was assessed at hospital admission, HDU admission, and at discharge from the HDU. The primary data source was the HDU patient chart, with data cross-checked with the hospital patient charts and the HDU admission book for quality control purpose. Data on hospital deliveries, admissions, and mortality were extracted from the hospital register and the maternal mortality hospital database. Data were retrospectively collected by a study physician (Claudia Marotta) and included patient demographics; admission date and source; main reason for admission in hospital (classified as by the WHO handbook on monitoring emergency obstetric care)¹² was complication of abortion, antepartum hemorrhage (APH), ectopic pregnancy, obstructed labor, postpartum hemorrhage (PPH), PE/eclampsia, puerperal sepsis, uterine rupture (UR), and others; and main reason for admission to the HDU was classified at the source as hemodynamic instability, sepsis, hemorrhage, acute renal failure, neurological impairment, respiratory distress, severe malaria, coagulopathy, or other diagnoses. These were standardized diagnoses based on the clinical assessment of the attending physician and thus not based on strict research case definitions.

Vital signs and treatments collected at admission included body temperature; heart rate (HR); respiratory rate (RR); neurological status according to the alert, voice, pain unresponsive (AVPU) scale; systolic blood pressure (SBP) and diastolic blood pressure (DBP); and transcutaneous peripheral saturation (SpO₂). The ratio between SpO₂ and fraction of inspired oxygen (SpO₂/FiO₂) was computed to better assess oxygenation in patients receiving oxygen. A modified OEWS was also computed from vital parameters.¹³

Specific treatments received at any point during HDU stay were extracted from the patient file and included oxygen supplementation, use of vasopressors, whole blood transfusions, antibiotic therapy, use of magnesium sulfate for eclamptic seizure prevention, and use of hydralazine for

antihypertensive purposes. Point-of-care laboratory parameters such as capillary lactate levels and hemoglobin (Hb) levels were collected when available. Date and time of hospital admission were collected whenever available. Length of stay in the HDU and patient outcomes (classified as death in the HDU, discharge to ward, or transfer to other facility) were reported at discharge.

Definitions. The modified OEWS uses core physiological parameters such as SBP and DBP, HR, RR, and temperature to identify deteriorating obstetric patients' demanding extra attention.¹³ The OEWS used in this study, as well as in the hospital at the time of the data collection, ranges from 0 to 10 points, with a green color code granted with a total OEWS of 1–2, a yellow color code for total OEWS of 3–5, and a red color code attributed to any patient with a OEWS above 5, or any danger sign (any among a SBP > 160 mmHg or < 80 mmHg, a DBP of > 110 mmHg, an HR < 60 or > 120, an RR > 31 or < 10, and a body temperature > 38.5°C or < 35°C). Patients were stratified according to severity on HDU admission in two groups, that is, with patients having a red OEWS in one group and patients having a green or yellow OEWS in the less severe group.

The AVPU scale is a simplification of the Glasgow Coma Scale useful to rapidly grade a patient's gross level of mental status based on four criteria (alert, verbally responsive, responsive to painful stimulus, and unresponsive). The ratio between SpO₂ and FiO₂ was computed by deriving FiO₂ from the oxygen therapy in liters by the following formula: $FiO_2 = 0.21 + O_2 \text{ (L/minute)} \times 0.03$.¹⁴ Death during HDU stay was defined as death occurred from referral to the HDU to discharge from the HDU. Hospital mortality was defined as death occurring during the whole hospital stay. Time from admission to hospital to referral to the HDU was computed from the relevant variables whenever these were available.

Statistical analysis. No formal sample size was calculated a priori, and the study included all women admitted during the first year of activity of the HDU. Continuous data were expressed as median and interquartile range (IQR), and categorical data as number and percentage. Mortality rate, AVPU classification, and OEWS score were compared among reasons for referral to the HDU using the chi-square test. The proportion of patients admitted with a red code per HDU bed per week was calculated by dividing the number of patients with a red code per HDU bed over the study period. Patients with a red code at the admission were compared with the ones presenting with a yellow or green code.

The association between mortality and each clinically relevant variable was explored using logistic regression models (unadjusted analysis). Independent risk factors for mortality were investigated using a logistic regression model including a set of candidate predictors at admission (adjusted analysis). The limited number of deaths restricted the number of candidate predictors that could be included in the first stage of model selection. Because of collinearity with the OEWS, some variables (temperature, HR, RR, SpO₂/FiO₂ ratio, SBP and DBP) were not included in the model.¹⁵ Other variables (age, Hb, admission during night, and weekend admission) were not included in the model according to unadjusted analysis of mortality. The final model included source of admission, OEWS, SpO₂, AVPU, use of oxygen, and use of vasopressors at admission. Model selection was performed by Akaike's

information criterion reduction. Effect sizes were presented as odds ratios (OR) with 95% CIs.

All analyses were two-sided, and a *P*-value less than 0.05 was considered statistically significant. Statistical analysis was performed using *R* 3.5 (R Foundation for Statistical Computing, Vienna, Austria).¹⁶

RESULTS

Patients. In the year the study ran, 523 patients (median age 25 years, IQR: 21–30 years) were admitted to the HDU. The incidence of HDU admissions was 72 per 1,000 deliveries, which equates to 7.2% or one HDU admission per 14 deliveries. Before referral to the HDU, admission to the hospital was because of PE or eclampsia (117 women, 22.4%), APH, including abruptio placentae or placenta previa (85 women, 16.3%), UR (55 women, 10.5%), PPH (66 women, 12.6%), ectopic pregnancy (53 women, 10.1%),

puerperal sepsis (49 women, 9.4%), obstructed labor (28 women, 5.4%), complications of abortion (12 women, 2.3%), or other diagnoses (58 women, 11.1%).

Patient characteristics at admission to the HDU stratified by severity level are reported in Table 1. Three hundred eighty-one patients (72.8%) received surgery (mainly caesarean section or laparotomy). The median time of arrival to the HDU was 9 hours (IQR: 3–38 hours), but it should be noted that this variable was often not reported (only in 39% of records). The most frequent reasons for referral to the HDU were hemodynamic instability (56.7%) and sepsis (12.4%). Half of the patients were alert at referral (51.3%), but the majority had a red OEWS (65.1%).

Patient characteristics at admission were not significantly different between patients with red versus green/yellow OEWS, except for HR, RR, SBP (included in the computation of OEWS), SpO₂, and SpO₂/FiO₂ ratio. The number of patients with a red code per HDU bed over the study period

TABLE 1
Patient characteristics at admission to the HDU of the Princess Christian Maternity Hospital

Characteristic	All patients (n = 523)	Red OEWS (n = 330)	Green or yellow OEWS (n = 177)	P-value
Admission characteristics				
Age (years)*†	25 (21–30)	25 (20–30)	26 (22–32)	0.08
Reason for referral to the HDU				0.38
Hemodynamic instability	297 (56.8)	181 (54.9)	107 (60.4)	–
Sepsis	65 (12.4)	45 (13.6)	18 (10.2)	–
Acute kidney failure	19 (3.6)	9 (2.7)	9 (5.1)	–
Neurological impairment	41 (7.8)	27 (8.2)	13 (7.3)	–
Respiratory distress	51 (9.8)	38 (11.5)	12 (6.8)	–
Severe malaria	9 (1.7)	6 (1.8)	3 (1.7)	–
Coagulopathy	23 (4.4)	15 (4.6)	7 (4.0)	–
Other diagnoses	18 (3.4)	9 (2.7)	8 (4.5)	–
Source				0.81
Operation room	346 (66.2)	216 (65.5)	119 (67.2)	–
Outpatient department	53 (10.1)	33 (10.0)	19 (10.8)	–
Ward	124 (23.7)	81 (24.5)	39 (22.0)	–
Admission time				
During night shift	156 (29.8)	97 (29.4)	53 (29.9)	0.98
During weekend	129 (24.7)	79 (23.9)	47 (26.6)	0.59
Clinical parameters				
Obstetric early warning score‡				
Green	110 (21.6)	0	110 (62.1)	–
Yellow	67 (13.2)	0	67 (37.9)	–
Red	330 (65.1)	330 (100.0)	0	–
Temperature (°C)*	36.5 (36.0–36.9)	36.5 (36.0–36.9)	36.4 (36.0–36.8)	0.30
Heart rate (beats/minute)*	113 (99–129)	125 (110–136)	100 (90–108)	< 0.0001
Respiratory rate (breaths/minute)*¶	28 (24–34)	32 (26–39)	24 (22–28)	< 0.0001
SpO ₂ (%)*§	98 (97–99)	98 (97–99)	98 (97–99)	0.008
SpO ₂ /fraction of inspired oxygen ratio*¶	467 (462–471)	467 (452–471)	467 (462–471)	0.001
Alert, voice, pain unresponsive scale#				0.07
Alert	259 (51.3)	160 (48.9)	99 (55.9)	–
Voice	73 (14.4)	42 (12.9)	30 (16.9)	–
Pain	69 (13.7)	48 (14.7)	21 (11.9)	–
Unresponsive	104 (20.6)	77 (23.5)	27 (15.3)	–
Systolic blood pressure (mmHg)*#	124 (110–142)	128 (110–151)	122 (110–136)	0.01
Diastolic blood pressure (mmHg)*#	78 (60–90)	79 (60–99)	76 (62–85)	0.15
Biology				
Capillary lactate levels (mmol/L)***	6.0 (3.5–10.1)	6.5 (3.5–11.3)	5.2 (2.6–7.7)	–
Hemoglobin (g/dL)*††	8.3 (6.4–10.5)	8.1 (6.1–10.6)	8.5 (7.0–10.49)	0.42

HDU = high dependency unit; OEWS = obstetric early warning score; SpO₂ = transcutaneous saturation of hemoglobin.

* Data expressed as *n* (%) or median (interquartile range).

† Data not available in 11 patients.

‡ Data not available in 16 patients.

§ Data not available in 15 patients.

|| Data not available in 17 patients.

¶ Data not available in 19 patients.

Data not available in 18 patients.

*** Data not available in 365 patients.

†† Data not available in 70 patients.

FIGURE 1. Number of patients and mortality rate by reason for referral to the high dependency unit. This figure appears in color at www.ajtmh.org.

was 82.5, representing 1.17 cases per HDU bed per week. During hospital stay, oxygen therapy was administered to 116 patients (22.2%), vasopressors to 68 (13.0%), transfusions to 263 (50.3%), antibiotics to 109 (20.8%), magnesium to 72 (13.8%), and hydralazine to 74 (14.1%). Main treatments administered in the HDU classified by the reason of admission to the HDU are reported in Supplemental Table 1.

Outcome. Fifty-five patients died in the HDU (10.5%), of whom 72.7% died within 24 hours from HDU admission. Thirty-two (58.2%) patients died during night shift, and 15 (27.3%) patients died during weekend days. Hospital mortality was 10.7%, as one patient deceased in the ward after HDU discharge. The specific HDU mortality rate was different among reasons for referral to the HDU ($P < 0.0001$), being lowest in patients with hemodynamic

TABLE 2
Unadjusted analysis of mortality

Variable	Dead (n = 55)	Alive (n = 468)	Odds ratio (95% CI)	P-value
Age (years)*†	25 (21–34)	25 (21–30)	1.02 (0.98–1.07)	0.26
Source				0.0005
Operation room	23 (6.6)	323 (93.4)	Reference	
Outpatient department	10 (18.9)	43 (81.1)	3.26 (1.40–7.17)	
Ward	22 (17.7)	102 (82.3)	3.03 (1.6–5.68)	
Admission during night				0.90
No	39 (10.6)	328 (89.4)	Reference	
Yes	16 (10.3)	140 (89.7)	0.96 (0.51–1.75)	
Weekend admission				0.64
No	40 (10.2)	345 (89.8)	Reference	
Yes	15 (11.6)	114 (88.4)	1.16 (0.60–2.14)	
Obstetric early warning score‡				0.0008
Green	3 (2.7)	107 (97.3)	Reference	
Yellow	5 (7.5)	62 (92.5)	2.88 (0.68–14.41)	
Red	46 (13.9)	284 (86.1)	5.78 (2.06–24.14)	
SpO ₂ (%)*§	96 (90–98)	98 (97–99)	0.91 (0.88–0.94)	< 0.0001
Temperature (°C)*	36.4 (35.7–37.1)	36.5 (36.1–36.8)	1.24 (0.88–1.76)	0.23
Heart rate (beats/minute)*	120 (98–1,409)	112 (99–128)	1.01 (0.99–1.02)	0.38
Respiratory rate (movements/minute)*¶	32 (27–45)	28 (24–34)	1.02 (1.00–1.04)	0.03
SpO ₂ /fraction of inspired oxygen ratio*¶	438 (237–462)	467 (462–471)	0.99 (0.99–0.99)	< 0.0001
Alert, voice, pain unresponsive#				< 0.0001
Alert/vocal	17 (5.1)	315 (94.9)	Reference	
Pain/unresponsive	35 (20.2)	138 (79.8)	4.70 (2.58–8.86)	
Systolic blood pressure (mmHg)*#	113 (92–139)	125 (112–143)	0.98 (0.97–0.99)	0.0001
Diastolic blood pressure (mmHg)*#	65 (40–80)	79 (60–91)	0.97 (0.96–0.98)	0.0001
Hemoglobin (g/dL)***	8.0 (6.0–10.4)	8.3 (6.5–10.5)	0.95 (0.85–1.06)	0.36
Oxygen at admission				< 0.0001
No	36 (8.0)	416 (92.0)	Reference	
Yes	19 (26.8)	52 (73.2)	4.22 (2.23–7.84)	
Vasopressors at admission				< 0.0001
No	42 (8.6)	446 (91.4)	Reference	
Yes	13 (37.1)	22 (62.9)	6.27 (2.89–13.23)	

SpO₂ = transcutaneous saturation of hemoglobin. Bold values indicate statistically significant results.

* Data expressed as n (%) or median (interquartile range).

† Data not available in 11 patients.

‡ Data not available in 16 patients.

§ Data not available in 15 patients.

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¶ Data not available in 19 patients.

Data not available in 18 patients.

** Data not available in 70 patients.

instability (4%) and highest in those with coagulopathy (35%) (Figure 1).

Four of five patients ($n = 428$, 81.9%) improved and were transferred to the ward after a median stay of 2 (IQR: 1–3) days. A total of 6.3% patients were transferred to an external ICU or to other hospitals after a median stay of 2 (IQR: 1–4) days, and only seven patients (1.3%) were discharged directly to home after a median stay of 5 (IQR: 4–6) days.

Factors associated with HDU mortality. At unadjusted analysis (Table 2), mortality was associated with referral from an outpatient department or ward ($P = 0.0005$), and with admission in a yellow or red OEWS code ($P = 0.0008$). Mortality was also associated with low SpO_2 ($P < 0.0001$), high RR ($P = 0.03$), hypertensive disorders ($P = 0.0001$), and being responsive to pain or unresponsive on the AVPU scale ($P < 0.0001$). Mortality was higher in patients receiving oxygen ($P < 0.0001$) or vasopressors ($P < 0.0001$) at admission.

At multivariable analysis (Table 3), being referred from the ward rather than being postoperative (OR: 3.21; 95% CI: 1.48–7.01), red OEWS code (OR: 3.66; 95% CI: 1.15–16.96), being responsive to pain or unresponsive on the AVPU scale (OR: 5.25; 95% CI: 2.64–16.96) at admission, and use of vasopressors at admission (OR: 3.24; 95% CI: 1.32–7.66) were independent risk factors for mortality, whereas higher SpO_2 (OR: 0.95; 95% CI: 0.91–0.99) was associated with increased survival.

DISCUSSION

The findings of this study can be summarized as follows: 1) in a low-resource referral maternity hospital, one of 14 deliveries needed critical care attention, with a crude mortality rate of 10.5%; 2) independent predictors of mortality were poor neurological status, a red OEWS code at admission to the HDU, and the use of vasopressors during the stay; and 3) higher oxygenation was associated with survival.

TABLE 3
Multivariable analysis of mortality

Variable	Odds ratio (95% CI)	P-value
Source		
Operation room	Reference	–
Outpatient department	2.18 (0.76–5.77)	0.13
Ward	3.21 (1.48–7.01)	0.003
OEWS		
Green	Reference	–
Yellow	3.14 (0.68–17.57)	0.15
Red	3.66 (1.15–16.96)	0.04
SpO_2 (%)	0.95 (0.91–0.99)	0.007
Alert, voice, pain unresponsive		< 0.0001
Alert/vocal	Reference	
Pain/unresponsive	5.25 (2.64–10.94)	
Oxygen at admission		0.14
No	Reference	
Yes	1.82 (0.81–3.93)	
Vasopressors at admission		0.008
No	Reference	
Yes	3.24 (1.32–7.66)	

AIC = akaike information criterion; FiO_2 = fraction of inspired oxygen; OEWS = obstetric early warning score; SpO_2 = transcutaneous saturation of hemoglobin. Bold values indicate statistically significant results. Because of collinearity with the OEWS, some variables (temperature, heart rate, respiratory rate, $\text{SpO}_2/\text{FiO}_2$, systolic blood pressure, and diastolic blood pressure) were not included in the model. Other variables (age, hemoglobin, admission during night, and weekend admission) were not included in the model according to unadjusted analysis of mortality. Finally, model selection was performed by AIC reduction.

In our study, we report data from an obstetric African HDU and represent to date the largest cohort of critically ill parturients from a low-income country. Other strengths of this study were the attempt to build a consecutive patient cohort, the moderately long time frame of observation, and the referral status of the hospital, allowing a comprehensive picture of this vulnerable patient group.

The rate of HDU admission was much higher than that in previous reports involving ICUs rather than HDUs.^{17–19} This is consistent with both the higher burden of obstetric critical care in Sierra Leone¹ and the intermediate level of care of the HDU compared with the ICU. In particular, this study was conducted in the HDU of an urban high-volume maternity hospital and the only one qualified for CEmOC in an entire region. Low-resource countries have a disproportionately greater share of obstetric critical illness, and yet critical care facilities remain scarce. This is shown in several ICU cohort studies from Nigeria.^{17,20,21} In fact, whereas in high-resource countries around 0.9–1% of pregnant women require ICU admission, these figures may rise up to 10% in low-resource countries.²² Also, nonstandardized admission criteria for both the HDU and ICU should be considered as a determinant of variability in obstetrics comparative epidemiology.²³ Although a consensus on obstetric critical care admission criteria would be helpful, this is difficult to define because these are heavily influenced by the conditions of the single institution and country.²⁴

Specific causes of HDU admission are comparable with other cohorts,^{17,19,20,25,26} with hemorrhage (both APH and PPH), severe PE, and sepsis representing the most significant burden. Of note, UR as a reason for critical care referral significantly affected this cohort in Sierra Leone, with one in 10 patients admitted with this potentially fatal condition. This finding confirms how this extreme complication still affects African women even in urban centers with wide access to primary care, as was also highlighted in a previous study on cesarean section infections in the same hospital.²⁷

Critically ill parturients managed in the HDU were extremely young, even younger than reported from other countries,^{25,28} and necessitated for critical attention for approximately 2 days. This relatively short time is in line with other ICU-based investigations^{19,28,29} and promotes the cost-effectiveness of intermediate critical care interventions, especially seen the high burden of red OEWS codes on admission.

One in 10 admitted patients died in the HDU, mainly within the first 24 hours of admission and during night shifts. As for the higher mortality during night shifts, it is known that understaffing and other organizational hurdles may influence the risk of maternal deaths.³⁰ Following these findings, quality improving initiatives were proposed to standardize the nurse-led patient admission process, improve the handover procedures and task shifting,³¹ and facilitate the prompting of the physician on call. The figure on mortality is higher than that reported in cohort studies from high-resource countries, where less than 5% of obstetric patients admitted to the ICU had a poor outcome.¹⁹ However, it is a crude mortality rate comparable with previous investigations in India and Nigeria^{6,21} that spotlight the still alarming hospital mortality of critically ill women. Of note, the limitation in resources to support failing organs (e.g., mechanical ventilation and renal replacement therapy) and the frequent late arrival of patients

may have also contributed to the worse outcome compared with that in other cohorts.

The main predictors for HDU mortality were in line with results from a recent systematic review of early warning systems that retained a high predictive capacity for maternal death among critically ill obstetric patients.²⁸ Despite the intra-operative derangements and risk of postoperative complications, the referral from the operating room was less likely associated with poor outcome than medical admissions. This relatively unexpected finding prompts to further refinements of early referral systems to allow for early centralization of unstable medical patients who should not be left under the responsibility of an overwhelmed and under-resourced ward team. The HDU under study had no access to mechanical ventilators, and thus, the positive modifiable effect of higher SpO₂ is attributable uniquely to careful oxygen therapy.

Our study has several limitations. First, the retrospective design limited the availability of some clinically relevant variables such as parity, details on antenatal care, socioeconomic information, and fetal outcomes that were not collected in HDU charts.^{32,33} Also, an investigation on neonatal health from critically ill mothers would have been of great interest.³⁴ Second, although reason for admission in the HDU was similar to that reported in other cohorts,²² the generalizability of the findings is limited to similar settings with extreme maternal mortality. These are, however, the settings where data are most lacking and thus needed. Third, as for all retrospective investigations, no quality control or standardized procedures were applicable on the collection of vital parameters and other variables. Fourth, the exact discharge ward for transfers was not detailed in the hospital charts. Finally, the number of outcome events restricted the number of candidate predictors that could be included in the first stage of model selection.

In conclusion, these findings tackle the scarcity of data on in-hospital obstetric critical illness and mortality. Clinicians and policy makers may use these findings to prioritize simple critical care interventions to address maternal mortality in a high-burden scenario.

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