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Determinants of maternal near-miss in private hospitals in eastern Ethiopia: A nested case–control study

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Abstract

Objective: Maternal near-miss refers to a woman who nearly died but survived complications in pregnancy, childbirth, or within 42 days of termination of pregnancy. The study of maternal near-miss has become essential for improving the quality of obstetric care. The objective of this study was to identify the determinants of maternal near-miss among women admitted to major private hospitals in eastern Ethiopia.

Method: An unmatched nested case–control study was conducted in major private hospitals in eastern Ethiopia from 5 March to 31 March 2020. Cases were women who fulfilled the sub-Saharan African maternal near-miss criteria and those admitted to the same hospitals but discharged without any complications under the sub-Saharan African maternal near-miss tool were controls. For each case, three corresponding women were randomly selected as controls. Factors associated with maternal near-misses were analyzed using binary and multiple logistic regressions with an adjusted odds ratio along with a 95% confidence interval. Finally, p-value < 0.05 was considered as a cut-off point for the significant association.

Results: A total of 432 women (108 cases and 324 controls) participated in the study. History of prior cesarean section (AOR = 4.33; 95% CI = 2.36–7.94), anemia in index pregnancy (AOR = 4.38; 95% CI = 2.43–7.91), being $\geqslant 35$ years of age (AOR = 2.94; 95% CI = 1.37–6.24), not attending antenatal care (AOR = 3.11; 95% CI = 1.43–6.78), and history of chronic medical disorders (AOR = 2.18; 95% CI = 1.03–4.59) were independently associated with maternal near-miss.

Conclusion: Maternal age $\geqslant 35$ years, had no antenatal care, had prior cesarean section, being anemic in index pregnancy, and have history of chronic medical disorders were the determinants of maternal near-miss. Improving maternal near-misses requires strengthening antenatal care (including supplementation of iron and folic acid to reduce anemia) and prioritizing women with a history of chronic medical illnesses. Interventions for preventing primary cesarean sections are crucial in this era of the cesarean epidemic to minimize its effect on maternal near-miss.

Keywords

determinants, Ethiopia, maternal near-miss, private hospitals

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Introduction

With the overall reduction of maternal deaths in high resource settings and the need to improve quality of care in low-resource settings, the study of women who survived complications (maternal near-miss, MNM) has become common since the 1990s.[1] MNM refers to a woman who nearly died but survived severe complications during pregnancy, childbirth, or within 42 days of termination of pregnancy.[1] It

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serves as a proxy for better knowledge about a set of conditions and preventable factors of maternal death.[2]

Studying MNM addresses the limitation of mortality only: under-reporting[3] and rare in absolute number.[4] In addition to having similar characteristics with maternal deaths, MNM is less threatening to report and less likely to blame because the women survived.[4,5] Therefore, studying MNM for countries, such as Ethiopia—with high maternal mortality[6] but significant under-reporting[3]—is not only for increasing the number of cases to be included and to address problems of under-reporting but also to create a conducive environment in the *no mother should die era*.[7]

Until 2009, when the World Health Organization (WHO) proposed the MNM criteria, studies on MNM used different identification criteria. However, those studies refer to similar concepts: women surviving severe complications. Although frequently used in MNM studies, including in low-resource settings, the WHO MNM tool underestimates the burden of MNM in low-resource settings.[8–10] Hence, a modified MNM criterion for use in low-resource settings of sub-Saharan Africa was proposed in 2017.[11] The modified MNM criteria called the sub-Saharan African MNM criteria contain 27 indicators grouped into the clinical-, laboratory-, and management-based approaches following the 2009 WHO MNM approach.[11] The tool has already been tested in three studies in Ethiopia,[12] Namibia,[13] and Suriname[14] and found that effective for MNM studies in low-resource settings.

In addition, to focus on determining the prevalence and associated factors of MNM,[12,15–19] existing MNM studies in Ethiopia are limited to public facilities. Given significant demographic, obstetrics, and medical characteristic differences between women in public and private hospitals, such studies failed to identify peculiar factors of private facilities. In this study, we report the determinants of MNM nested in a larger retrospective cohort conducted in major private hospitals in eastern Ethiopia.[20]

Methods

Study settings

This study was an unmatched case–control study nested in a large cohort of women admitted to two major private hospitals in eastern Ethiopia (Harar General Hospital and Bilal General Hospital). The hospitals were selected because of having a high number of annual deliveries, having qualified consultants for the care of women with life-threatening complications, such as emergency cesarean section (CS), and having an established intensive care unit. There were 1167 live births and 1214 maternity admissions during the 1-year study period in both hospitals. Details of the baseline study have been described elsewhere.[20] In brief, through a review of all maternity admissions during the study period, women who developed MNM per the sub-Saharan African MNM tool were identified. The data collection period was from 5 March to 31 March 2020.

Populations

The source populations were women who were admitted to private hospitals in eastern Ethiopia during pregnancy, childbirth, or within 42 days of termination of pregnancy. The study populations were women who were admitted from 9 January 2019 to 8 January 2020 in selected hospitals in eastern Ethiopia during pregnancy, childbirth, or within 42 days of termination of pregnancy.

Inclusion and exclusion criteria for cases and controls

Cases. Women who were admitted in the selected hospitals during the study period during pregnancy, childbirth, or within 42 days of termination of pregnancy and fulfilled at least one of the MNM conditions as per the sub-Saharan African MNM criteria (Table 1).[11] Women whose medical records missed important variables were excluded.

Controls. Women admitted to the same hospitals and discharged without any complications under the sub-Saharan African MNM tool were controls. Similarly, women whose medical records missed important variables were excluded.

Sample size determination

The sample size was estimated using Epi Info 7 Statcalc software for an unmatched case–control study with the assumption of a 95% confidence interval, power of 80%, and case to the control ratio of 1:3. The proportion of case and control with exposure (prior history of CS) was 22.5% and 8.7%, respectively, and AOR of 3.53 from a previous study in Ethiopia.[18] The minimum sample size with 10% non-response was 332 (83 cases and 249 controls). We included all women with near-miss cases during the study period to increase the power of the study.

Sampling technique and procedure

Maternal admissions during pregnancy, childbirth, or within 42 days of termination of pregnancy during the study period were 1214 (cases = 108 and controls = 1106) in both hospitals. All cases (n = 108) admitted during the study period were included in the study. For the selection of controls, we prepared a sampling frame using their unique medical registration number. Then, a computer-generated random sampling technique was applied to select controls. For each case, three corresponding women were selected randomly as controls.

Data collection

Data were collected using the validated sub-Saharan African MNM criteria by trained research assistants.[11–13] Detailed socio-demographic characteristics, obstetrics history,

Table 1. Sub-Saharan African MNM criteria.[l]

Clinical-based criteria	Laboratory-based criteria	Management-based criteria
Acute cyanosis[a]	Oxygen saturation < 90% for > 60 min	Hysterectomy following infection or hemorrhage
Gasping[b]	Creatinine ⩾ 300 μmol/L or ⩾ 3.5 mg/dL	Transfusion of ⩾ 2 units of red blood cells
Respiratory rate > 40 or < 6/min	Acute thrombocytopenia (<50,000 platelets/mL)	Intubation and ventilation for 60 min not related to anesthesia
Shock[c]	Loss of consciousness and ketoacids in urine	Cardiopulmonary resuscitation
Oliguria nonresponsive to fluids or diuretics[d]		Laparotomy other than for cesarean section
Failure to form clots[e]		
Loss of consciousness lasting ⩾ 12 h[f]		
Cardiac arrest		
Stroke[g]		
Uncontrollable fit/total paralysis[h]		
Jaundice in the presence of pre-eclampsia[i]		
Eclampsia[j]		
Uterine rupture[k]		
Sepsis or severe systemic infection[l]		
Pulmonary edema[m]		
Severe abortion complications[n]		
Severe malaria[o]		
Severe pre-eclampsia with ICU admission		

[a]Acute cyanosis is blue or purple coloration of the skin or mucous membranes due to low oxygen saturation.
[b]Gasping is a terminal respiratory pattern, and the breath is convulsively and audibly caught.
[c]Shock is persistent severe hypotension, defined as a systolic BP < 90 mmHg for ⩾ 60 min with a pulse rate of at least 120 despite aggressive fluid replacement (>2L).
[d]Oliguria is defined as a urinary output < 30 mL/h for 4 h or < 400 mL/24 h.
[e]Failure to form clots can be assessed by the bedside clotting test or absence of clotting from the IV site after 7–10 min.
[f]Loss of consciousness lasting > 12 h is a profound alteration of mental state that involves complete or near-complete lack of responsiveness to external stimuli. It is defined as a Glasgow Coma Scale < 10 (moderate or severe coma).
[g]Stroke is a neurological deficit of cerebrovascular cause that persists beyond 24 h or is interrupted by death within 24 h.
[h]Uncontrolled fits/total paralysis is refractory, persistent convulsions or status epilepticus.
[i]Pre-eclampsia is defined as the presence of hypertension associated with proteinuria. Hypertension is defined as a BP of at least 140/90 mmHg on at least two occasions and at least 4–6 h apart after the 20th week of gestation in women known to be normotensive beforehand. Proteinuria is defined as excretion of 300 mg or more of protein every 24 h. If 24-h urine samples are not available, proteinuria is defined as a protein concentration of 300 mg/L or more (⩾ 1 on dipstick) in at least two random urine samples taken at least 4–6 h apart.
[j]Eclampsia is diastolic BP ⩾ 90 mmHg or proteinuria + 3 and convulsion or coma.
[k]Uterine rupture is a complete rupture of the uterus during labor and/or confirmed later by laparotomy.
[l]Sepsis or severe systemic infection is defined as a clinical sign of infection and three of the following: temperature > 38°C or < 36°C, respiration rate > 20/min, pulse rate > 90/min, WBC > 12,000.
[m]Pulmonary edema is the accumulation of fluids in the air spaces and parenchyma of the lungs.
[n]Severe abortion complications are defined as septic in incomplete abortion, a complicated gestational trophoblastic disease with anemia.
[o]Severe malaria is defined as major signs of organ dysfunction and/or high-level parasitemia or cerebral malaria.

preexisting medical conditions, MNM events, and underlying complications were collected by reviewing the medical records of women. The dependent variable was MNM, defined as the presence of any of the sub-Saharan African MNM criteria.[11] Independent variables were demographic characteristics, such as residence, age, referral status, and marital status; obstetrics histories, such as parity, history of prior CS, history of abortion, history of stillbirth, antenatal care (ANC) utilization, anemia in index pregnancy, and history of chronic medical disorders.

Data management and analysis

Data were cleaned and entered into EpiData 3.1 and then exported to SPSS 20 for analysis. Frequency tables and mean were used to describe the characteristics of the study participants for categorical and continuous variables, respectively. Bivariate analysis was used to identify potential variables for the multivariable logistic regression model. Independent variables with a p-value of ⩽ 0.25 were entered into a multiple logistic regression model. The goodness of model fitness was checked using the Hosmer–Lemeshow statistic (0.456). Adjusted odds ratio along with 95% CI was used to describe the association in the multiple logistic regressions. Finally, p-value < 0.05 was considered as a cut-off point for the statistically significant association.

Ethical considerations

The Institutional Health Research Ethics Review Committee of the College of Health and Medical Sciences, Haramaya University in Ethiopia, approved this study (Ref No: IHRERC/045/2020). As the study was retrospective, the

Table 2. Socio-demographic characteristics of women admitted in private hospitals in eastern Ethiopia, 2020 (n = 432).

Variable	Category	Total		Cases (n = 108)		controls (n = 324)		p-value
		N	%	N	%	N	%	
Age in years	<20	28	6.5	9	8.3	19	5.9	0.000
	20–34	358	82.9	74	68.5	284	87.7	
	⩾35	46	10.6	25	23.2	21	6.4	
Residence	Urban	284	65.7	65	60.2	219	67.6	0.100
	Rural	148	34.3	43	39.8	105	32.4	
Marital status	Single	14	3.2	6	5.6	8	2.5	0.108
	Married	418	96.8	102	94.4	316	97.5	
Referral status	Self-referral	410	94.9	87	80.6	323	99.7	0.000
	Referred	22	5.1	21	17.4	1	0.3	

need for individual informed consent was waived. We submitted a support letter to participating hospitals and got permission. Data collection was anonymous to maintain the confidentially of participants.

Results

Socio-demographic characteristics of participants

A total of 432 women (108 cases and 324 controls) participated in the study. The mean age of respondents was 28.9 (±6.2) and 26.4 (±4.9) years among cases and controls, respectively. The majority of the respondents were 20–34 years of age (68.5% cases and 87.7% controls) and married (97.5% cases and 94.4% controls). Referral from other health facilities was significantly higher among cases than controls ($p < 0.0001$). However, there was no significant difference in place of residence and marital status ($p > 0.05$) (Table 2).

Obstetrics and medical conditions of participants

The majority of respondents were multiparous (68.5% of cases and 59.3% of controls). Compared to controls, women with MNM were more likely to have a history of previous CS, abortion, and stillbirth ($p < 0.05$). In addition, CS was more likely among cases than controls (63% versus 22.5%, $p < 0.0001$). Anemia in index pregnancy and history of chronic medical disorders were higher among MNM cases than controls ($p < 0.05$). But no significant differences exist about parity ($p > 0.05$) (Table 3).

Underlying complications among cases

Obstetric hemorrhage (50%) was the leading underlying complication followed by hypertensive disorders of pregnancy (27.8%) among cases (Table 4).

Determinants of MNM

In the adjusted analysis, age, ANC, prior history, anemia in the index pregnancy, and history of chronic medical disorders independently associated with MNM. The odds of having a previous CS were 4.33 times higher among cases than controls (AOR = 4.33; 95% CI = 2.36–7.94). Similarly, the odds of having anemia in index pregnancy and being ⩾35 years of age were 4.38 (AOR = 4.38; 95% CI = 2.43–7.91) and 2.94 (AOR = 2.94; 95% CI = 1.37–6.24) times higher among cases than controls, respectively. The odds of not attending ANC were also three (AOR = 3.11; 95% CI = 1.43–6.78) times higher among near-miss cases than controls. In addition, a history of chronic medical disorders was 2.18 times more likely among near-misses than controls (AOR 2.18; 95% CI = 1.03–4.59) (Table 5).

Discussion

In this unmatched nested case–control study, we have identified the determinants of MNM among women attending maternity units in major private hospitals in eastern Ethiopia. This study revealed that MNM cases were more likely to be older than controls. This finding is consistent with the previous studies.[14,21–23] The reason might be related to a greater risk of hypertensive disorders of pregnancy, CS, or postpartum hemorrhage among older women.[24,25] Those obstetrics complications lead to MNM. Compared to controls, women with MNM were less likely to receive ANC. This finding is in line with the previous study in Ethiopia,[17,18] Nigeria,[26] and Brazil.[27] It indicates the importance of ANC in identifying pregnancy complications and providing early treatment for reducing the occurrence of MNM.[28]

Consistent with the findings from Ethiopia,[15,18,29] Tanzania, and Brazil,[27,30] women with MNM were more likely to have a previous history of CS. A prior CS increases the risk of uterine rupture or placenta previa in subsequent pregnancies, which leads to MNM.[31] In

Table 3. Obstetrics and medical conditions of women with and without MNM admitted in private hospitals in Eastern Ethiopia, 2020 (n = 432).

Variable	Category	Total		Cases (n = 108)		Controls (n = 324)		p-value
		N	%	N	%	N	%	
Parity	Primiparous	166	38.4	34	31.5	132	40.7	0.054
	Multiparous	266	61.6	74	68.5	192	59.3	
Received ANC	Yes	393	91.0	92	85.2	301	92.9	0.016
	No	39	9.0	16	14.8	23	7.1	
History of still birth	Yes	35	8.1	14	13	21	6.5	0.030
	No	397	91.9	94	87	303	93.5	
History of abortion	Yes	95	22	31	28.7	64	19.8	0.037
	No	337	78	77	71.3	260	80.2	
Previous CS	Yes	76	17.6	37	34.3	39	12	0.000
	No	356	82.4	71	65.7	285	88	
Gestational age at delivery (weeks)	<37	24	5.6	20	18.5	4	1.2	0.000
	37–42	403	93.3	86	79.6	317	97.8	
	>42	5	1.2	2	1.9	3	1.0	
Mode of delivery	Vaginal	258	59.7	32	29.6	226	69.8	0.000
	CS[b]	164	40.3	76	70.4	98	30.2	
Anemia in the index pregnancy	Yes	77	17.8	42	38.9	35	10.8	0.000
	No	355	81.2	66	61.1	289	89.2	
History of chronic medical disorders[a]	Yes	42	9.7	16	14.8	26	8.0	0.034
	No	390	90.3	92	85.2	298	92.0	
Chronic hypertension	Yes	34	7.9	14	13.0	20	6.2	0.030
	No	398	92.1	94	87.0	304	93.8	
Preexisting diabetes mellitus	Yes	5	1.2	2	1.9	3	0.9	0.367
	No	427	98.8	106	98.2	321	99.2	
Cardiovascular disease	Yes	3	0.7	1	0.9	2	0.6	0.579
	No	429	99.3	107	99.1	322	99.4	

N: number; ANC: antenatal care; CS: cesarean section.
[a]Chronic hypertension, preexisting diabetes mellitus, and cardiovascular disease.
[b]Includes laparotomy (n = 4).

Table 4. Underling complications of MNM among women admitted in private hospitals in eastern Ethiopia, 2020 (n = 108).

Underlying complication	N	%
Obstetric hemorrhage	54	50
Abortion related	7	6.5
Ectopic pregnancy	4	3.7
Abruptio placenta	18	16.7
Placenta previa	7	6.5
Uterine rupture	8	7.4
Severe postpartum hemorrhage	12	11.1
Hypertensive disorders	30	27.8
Eclampsia	18	16.7
Pre-eclampsia	12	11.1
Sepsis/severe systemic infection	26	24.2

addition, CS increases the risk of infection and hemorrhage,[32] thereby increasing the odds of near-miss events. This finding suggests considering potential risks of CS during assessment or decision for CS.

Women with a history of chronic medical disorders had higher odds of MNM. This finding is consistent with a study done in Ethiopia.[18] Chronic medical disorders during pregnancy, such as chronic hypertension, increased the risk of severe pregnancy complications, such as superimposed pre-eclampsia and placental abruption.[33] In addition, women with anemia in index pregnancy had higher odds of experiencing MNM. This finding is congruent with the studies in Ghana and Ethiopia.[17,34] It might be because the minimum amount of bleeding in anemic patients may lead to severe postpartum hemorrhage and hypovolemic shock leading to MNM. Nutritional intervention and iron supplementation for all women during pregnancy may help to prevent and improve anemia during pregnancy.[35]

This study was the first study in Ethiopia to document the determinants of MNM in private hospitals using the newly developed and validated MNM criteria.[11] The use of nested case–control within a large cohort of study[20] enabled us to draw a strong conclusion about any association. However, some socio-demographic characteristics (income,

Table 5. Determinants of MNM among women admitted in private hospitals of eastern Ethiopia, 2020.

Variable	Category	MNM status		COR (95% CI)	AOR (95% CI)
		Cases, n (%) (n = 108)	Controls, n (%) (n = 324)		
Age in years	20–34	74 (68.5)	284 (87.7)	1.0	1.0
	<20	9 (8.30	19 (5.9)	1.82 (0.79–4.18)	2.86 (1.11–7.42)***
	⩾35	25 (23.2)	21 (6.5)	4.57 (2.42–8.61)	2.92 (1.37–6.24)***
Residence	Urban	65(60.2)	219 (67.6)	1.0	1.0
	Rural	43 (39.8)	105 (32.4)	1.38 (0.88–2.16)	1.47 (0.87–2.48)
History of stillbirth	No	94 (87.0)	303 (93.5)	1.0	1.0
	Yes	14 (83.0)	21 (6.5)	2.15 (1.05–4.39)	1.69 (0.75–3.86)
History of Abortion	No	77 (71.3)	260 (80.2)	1.0	1.0
	Yes	31 (28.77)	24 (19.8)	1.64 (0.99–2.69)	1.53 (0.86–2.74)
ANC utilization	Yes	92 (85.2)	301 (92.9)	1.0	1.0
	No	16 (14.8)	23 (7.1)	2.27 (1.15–4.49)	3.11 (1.43–6.78)**
Parity	Primiparous	34 (31.5)	132 (40.7)	1.0	1.0
	Multiparous	74 (68.5)	192 (59.3)	1.40 (0.94–2.38)	0.92 (0.52–1.64)
Previous CS	No	71 (65.7)	285 (88)	1.0	1.0
	Yes	37 (34.3)	39 (12)	3.81 (2.27–6.40)	4.33 (2.36–7.94)****
Anemia in the index pregnancy	No	66 (61.1)	289 (89.2)	1.0	1.0
	Yes	42 (38.9)	35 (10.8)	5.26 (3.12–8.86)	4.38 (2.43–7.91)****
History of chronic medical disorders[a]	No	92 (85.2)	298 (92.0)	1.0	1.0
	Yes	16 (14.8)	26 (8.0)	1.99 (1.03–3.88)	2.18 (1.03–4.59)*

MNM: maternal near-miss; ANC: antenatal care; CS: cesarean section; COR: crude odds ratio; AOR: adjusted odds ratio.
*p = 0.041, **p = 0.004, ***p = 0.003, ****p ⩽ 0.001.
[a]Hypertension, diabetes mellitus, and cardiovascular disease.

educational status, partner's status, and occupation) were not included in our analysis since they are not routinely documented. Since data collection was retrospective from the medical records, our follow-up was limited up to the discharge of the women or 42 days of termination of pregnancy, whichever comes first. Therefore, MNM occurring among controls within 42 days might be misclassified—especially if the woman is not readmitted in those private hospitals. In addition, the lack of studies that utilized the sub-Saharan African MNM criteria made comparing our findings with others difficult.

Conclusion

Maternal age ⩾ 35 years, had no ANC, had prior CS, being anemic in index pregnancy, or having a history of chronic medical disorders were the determinants of MNM. Efforts to strengthen ANC are needed to prevent maternal near-misses. Supplementation of iron and folic acid during pregnancy is also crucial to reduce near-miss due to anemia. Interventions for preventing primary CSs are important in this era of the cesarean epidemic to minimize the burden of MNM or subsequent CSs.

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Author contributions

S.G.T. and A.K.T. conceived the study and wrote the original draft of the article; S.G.T. analyzed data and its interpretation; A.K.T. and N.A. supervised the proposal development, data collection, analysis, and overall work; A.K.T., N.A., and S.G.F. reviewed the draft article for intellectual content and participated in the revision. All authors read and approved the final version of the article.

Availability of data and materials

The dataset used or analyzed during this study is available from the corresponding author on reasonable request.

Declaration of conflicting interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Disclaimer

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Ethical approval

The Institutional Health Research Ethics Review Committee of the College of Health and Medical Sciences, Haramaya University in Ethiopia, approved this study (Ref no: IHRERC/045/2020).

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