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Determinants of Neonatal Near-Miss among Neonates of Postnatal Women in North Wollo Hospitals, Northern Ethiopia, 2022

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Abstract

Background: Children born with life-threatening conditions are more likely to die particularly during the neonatal period. Neonatal near-miss events are three to six times more frequent than neonatal deaths. However, there is limited evidence of this problem in sub-Saharan Africa, particularly Ethiopia. Therefore, this study aimed to identify the determinants of neonatal near misses among neonates delivered in public hospitals in the North Wollo Zone, Northern Ethiopia.

Methods: A facility-based unmatched case-control study was conducted from February 25 to April 25, 2022, on 453 participants. Consecutive and systematic sampling techniques were used. A pre-tested semi- structured interviewer-administered questionnaire and medical record review were used to collect the data. Data were entered using Epi Data Manager 4.6.6 and exported to SPSS version 26 for analysis. After performing bivariable logistic regression, variables with a p-value < 0.2 were entered into a multivariable logistic regression. Both Descriptive and inferential statistics were carried out, and finally, AOR together with 95% CI and p-value <0.05 were used to declare the significance of all statistics.

Result: The results showed that rural residents (AOR = 1.89, CI:1.05-3.39), no antenatal care follow-up (AOR = 4.77, CI:2.13-10.72), less than four antenatal care follow-ups (AOR =2.49, CI:1.13-5.49), birth interval of less than 2 years (AOR= 4.53, CI:2.32-8.83), pregnancy-induced hypertension (AOR=2.97, CI:1.35-6.48) and premature rupture of membranes (AOR= 2.94, CI:1.30-6.62) were determinants of neonatal near miss.

Conclusion: Rural residents, who did not have antenatal care follow-up, had fewer than four antenatal care follow-ups, birth intervals less than 2 years, pregnancy -induced hypertension, and premature rupture of membranes were determinants of neonatal near miss. Encouraging Antenatal care follow-up, adequate antenatal services, family planning utilization, and early screening and treatment of complications that occur during pregnancy is needed to improve neonatal health outcomes.

Keywords: Obstetric complications; Neonatal near miss; Neonatal mortality; Neonatal Near Miss assessment scale; Northern Ethiopia

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Background

Fetuses who survive life-threatening complications due to poor perinatal care share many characteristics with new-borns who die as a result of similar problems. This has given rise to the concept of neonatal near-miss (NNM) [1], which is described as a new-born who has a serious complication, almost dying, but who survived during the neonatal period [2]. It is a modern term that has arisen recently, and is equivalent to the concept of maternal near-miss (MNM). Three - eight times more frequently than neonatal deaths and NNM evaluations will also provide reasonable evidence of the causal mechanisms responsible for neonatal deaths [3]. NNM is a predictor of early neonatal death and is useful in preventing early neonatal mortality [4].

Children born with life-threatening conditions have a higher

chance of death particularly during the neonatal period. Even if they survive this crucial time after birth known as a neonatal near miss these children have the worst prognosis including infant mortality and possibly other negative outcomes [5].

Globally, the most common causes of neonatal near misses in health facilities are severe infection, low birth weight, and birth asphyxia [6]. Near misses increase the odds of death 12.7 times within 28 days [7].

Neonatal mortality is a major public health issue worldwide, particularly in low-income and middle-income countries (LMICs) [8]. Neonatal mortality has remained at the top of the agenda of public health and international development agencies [9].

To meet the challenge of achieving Sustainable Development Goal (SDG) targets, Ethiopia is trying to increase access to effective coverage of life-saving, high-impact neonatal and child health interventions through national-level plans, such as Growth and Transformation Plan (GTP) and health sector development plans (HSDPs) IV, to achieve the 2035 goal of reducing neonatal mortality rate (NMR) to less than 10 per 1000 live births [10]. Ethiopia initially hoped to lower its NMR from 29 per 1,000 live births in 2015/16 to 12 per 1,000 live births in 2019/2020, but the NMR increased to 30 per 1,000 live births in 2019 [11]. The highest mortality rate was observed in the Amhara Regional State, accounting for approximately 47 per 1,000 live births [12]. This is nine times higher than that in highly developed countries [13].

Identifying antenatal predictors or risk factors for NNM allows healthcare professionals and policymakers to establish focused interventions to avert or address these risk factors, reduce health issues in new-borns, promote best practices, and improve perinatal care quality [1]. It has also been suggested in the neonatal context as a way to accelerate progress toward the SDGs [14].

Previous studies have attempted to identify the determinants of neonatal near miss by using only two classes of parameters (pragmatic and management criteria) for identifying NNM cases, however, this study used six classes of parameters (cardio-respiratory, sensory and drug-related, neuro-renal, hepatic, lab-investigation and pragmatic domains) to identify NNM cases, which helps reduce the chance of missing neonatal near miss cases. Moreover, the determinant factors of neonatal near-miss have not been adequately investigated specifically in the study area; therefore, this study was aimed to identifying the determinants of neonatal near-miss among neonates of postnatal Women in North Wollo Hospitals, Northern Ethiopia.

Methodology

Study area

This study was conducted at public hospitals in the North Wollo Zone, Amhara National Regional State, Ethiopia. The North Wollo Zone is located in the Amhara region, with the capital city of Woldia located 521 km from Addis Ababa and 360 km from Bahirdar. The total population of the North Wollo Zone is 1,500,303, of whom 752,895 are men and 747,408 are women [15]. There are six public hospitals in the North Wollo Zone:- Woldia Comprehensive Specialized Hospital, Kobo Primary Hospital, Mersa Primary Hospital, Kiduse Lalibela General Hospital, Meket Shedo Primary Hospital, and Wadila Primary Hospital. The hospitals are open 24hrs a day to provide curative, emergency, maternal, and child health services. Each hospital provided specialty care for sick new-borns, with the capacity to provide bag and mask ventilation, oxygen, and incubator care using radiant warmers.

Study design and period

This facility-based unmatched case-control study was conducted in North Wollo Zone public hospitals, in North East Ethiopia from February 25 to April 25, 2022.

Population

Source population

Cases: All post-natal women with live neonates who were diagnosed with NNM in public hospitals in the North Wollo zone.

Controls: All post-natal women with live neonates who were not diagnosed with NNM in the North Wollo Zone public hospitals.

Study population

Cases: All post-natal women with live neonates who were diagnosed with NNM at North Wollo Public Hospitals during the study period.

Controls: All post-natal women with live neonates in North Wollo Public Hospitals who were not diagnosed with NNM during the study period.

Sampling technique and sample size

Sampling size determination

The sample size was calculated using Epi Info Version 7 software with a control-case ratio of 2:1 by considering the variables studied in different studies [2, 6, 16, 17]. The final sample size included 453 (302 controls and 151 cases).

Sampling technique and procedure

There were six public hospitals in the North Wollo Zone, and the sample size was allocated proportionally to each study area by considering their previous 2-month delivery report as a sample frame .and finally allocated the control to the case at a 2:1 ratio in each hospital. Cases were recruited consecutively until the full sample size, and controls were selected by a systematic sampling technique from a total of 1240 with a k value of 3. And based on their order of registration in the postnatal log book during discharge mothers were interviewed up to the desired sample. The first respondent was randomly selected from a post-natal log book.

Study variables

Dependent variable

Neonatal near miss

Independent Variables: Socio-demographic characteristics included maternal age, place of residence, marital status,

educational status of the mother, educational status of the husband, occupation, and family size, obstetric characteristics which including parity, birth interval, prenatal visits, complications during pregnancy, complications during labor and delivery, mode of delivery, fetal characteristics including presentation, meconium-stained amniotic fluid, sex of neonate, gestational age, and weight of the newborn, medical-related factors including DM, chronic HTN, anemia, cardiac, HIV, syphilis, malnutrition and substance use during pregnancy; cigarette smoking.

Operational definitions

Neonatal near miss: In this study, neonatal near miss was defined as a neonate who developed a severe complication in the first days of life and almost died but survived during the neonatal period [18]. And diagnosed by at least one of the Six classes of parameters 'cardio-respiratory domain (included seven items: Absence of regular breathing, respiratory rate > 70 bpm, Bradycardia < 80 bpm, positive pressure ventilation, nasal CPAP, Intubation for suctioning, and APGAR score less than 7 in the fifth minute), 'sensory and drug-related domains (including three items: Inability to suck within 12 h, use of corticosteroid for hypoglycaemia, and vasoactive drugs)', 'neuro-renal domain (included four items: neural tube defects, recurrent seizures, anuria greater than 6 h, and central cyanosis)', 'hepatic domain' (included three items: Serum bilirubin level > 10 mg/dl within 24 hrs., Jaundice in first 24 hrs., and Phototherapy within 24 hrs.), 'lab-investigation domain' (included three items: Hgb <10 g/dl, WBC < 4000 cells/mm3, and Blood glucose level < 40 mg/ dl in 24 h) and 'pragmatic domain' (included four items: first-week surgery, a gestational age of less than 34 weeks, a birth weight of less than 1750 g, and an auxiliary temperature 6-12 h less than 35°C) [19, 20, 4-8].

Smokers: Women were considered smokers if they reported smoking at least one cigarette per day or per trimester on tobacco products [21].

Nutritional status: MUAC measurements were used to determine the nutritional status of the lactating women. The mid-upper arm circumference of the left arm was measured using non-stretchable standard MUAC tape with no clothing on the arm. Undernourishment was considered when the MUAC of lactating women is < 23 cm ,and ≥ 23 cm was considered well-nourished [22].

Data collection tool and procedure

A semi-structured interviewer-administered questionnaire was developed by adapting the literature and considering the study's local situation and objectives. The questionnaire had four parts: (1) socio-demographic details of the mother; and (2) maternal profile, including present and past obstetric history, antenatal care (ANC), and supplements taken. complications during labor and delivery (3) neonatal characteristics, including neonate sex, birth weight, gestational age, presence of meconium-stained amniotic fluid at delivery, Apgar scores, complications during and after delivery, and any interventions performed for the newborn and (4) maternal medical and behavioral factors (presence of anemia, chronic hypertension, HIV, DM, and cardiac problems) and cigarette smoking.

Data were obtained through a combination of interviews with the mothers and in-patient hospital records of the mothers and babies and data were collected daily using the developed tool and by reviewing the medical records. The criteria to identify NNM were developed by reviewing different literature [3, 6, 14, 17, 20, 23-27], and the reliability of the neonatal near miss assessment scale (NNMAS) tool has an overall Cronbach's alpha of 0.80(14). The scale has 24 items that are categorized into dichotomous variables (yes/no). The questionnaires were checked by face validity experts. Data were collected by six trained midwives and six supervisors were assigned for supervision, and interviews were conducted after written consent was obtained.

Data quality control

One week before the actual data collection, a pre-test was conducted on 5 % [23] of samples from hospitals other than data collection site, and appropriate modification was made. After translation into the local language, Amharic, properly designed data collection tools were provided to the data collectors. The principal investigator provided training to data collectors and supervisors on the basic aspects of data collection, approaches, and the problem of confidentiality and privacy. A clear description of the study objectives and procedures was provided to the study participants to obtain accurate data. Daily meetings were held among data collectors, supervisors, and the principal investigator to discuss the day's activities and to check the completeness of the data.

Data processing and analysis

The Data were checked, coded, and entered into the Epi. DATA 4.6.6 versions and then exported into SPSS Windows version 26 for analysis. Descriptive data are summarized using frequencies, percentages and tables. Bivariable logistic regression analysis was performed for each independent variable, and multivariable logistic regression analysis was employed for a p-value less than 0.2 in Bivariable logistic regression to identify independent predictors of the outcome variable. Finally, variables with P-value less than 0.2 and fulfill the assumption of logistic regression from bi-variable logistic regression were considered for the multivariable logistic regression model. The determinants of NNM were determined in the final model with a p-value of <0.05, and a 95% CI with AOR. Hosmer Lemeshow goodness-of-fit tests were used to check the model's goodness of fit, and the variance inflation factor (VIF) was used to check for multicollinearity among the explanatory variables.

Results

Socio-demographic characteristics

In This study total of 151 cases and 302 controls were involved with a response rate of 100% for both cases and controls. The minimum and maximum ages at birth were 18 and 44 respectively and the mean age of the cases and controls were 26.92 with SD 7.67 and 26.16 with SD 6.54 respectively. Nearly 2/3rd of neonates of mothers among cases were from rural 103 (68.2%), and more than half of neonates of the mothers from control were urban in residency which accounts for 166(55.0%). Regarding marital status 288 (95.4%) and 141(93.4%) of mothers were living with

their partners among controls and cases respectively. Regarding maternal occupation 82 (54.3%) of mothers among cases and 148 (49.0%) of mothers among the control were housewives (**Table 1**).

Obstetric characteristics

Among mothers of neonates, 78(51.7%) and 172(57.0%) were multiparous in the case, and controls respectively. the birth interval between current and previous pregnancy in multipara mothers among cases, 50 (64.1%) of neonates of mothers gave birth less than 24 months from the last childbirth and among controls, 133(77.3%) of mothers of neonates give birth greater or equal to 24 months. Regarding ANC visits among controls, nearly 3/4th 226(74.8%) mothers of neonates have ANC visits at least once and among cases ,83(55%) mothers of neonates had at least one ANC visit, and Among cases 72(86.7%) of mothers of neonates had fewer than four antenatal care follow- up visits. Among cases, nearly 1/5th of mothers of neonates were diagnosed with PIH and PROM were 21.2% and 19.2% respectively. Regarding gestational age, 126(83.4%) and 253(83.8%) of neonates among case and controls were born between 37-41 completed weeks respectively. Concerning the weight of new-borns at birth 125(82.8%) and 259(85.8%) of neonates' birth weights were 2500gm-4000gms among cases and controls, respectively (**Table 2**).

Medical-related factors and Substance usage during pregnancy

In this study, 18(11.9%) and 28(9.3%) neonate's mothers were diagnosed with anemia among cases and controls, respectively. Regarding nutritional status 25(16.6%) of cases and 22(7.3%) of controls of neonate's mother were malnourished during (**Table 3**).

Neonatal Near Miss

Based on neonatal near miss assessment criteria, 71(47.0%), 63(41.7%), 49(32.5%), 40(26.5%), and 40(26.5%) of neonates had an absence of regular breathing, APGAR scores less than 7 in the fifth minute, intubation for suctioning, nasal CPAP and positive pressure ventilation respectively (**Table 4**).

Determinants of neonatal miss

Among the independent variables: age of mother, maternal occupation, maternal level of education, residency, ANC visits, number of ANC visits, birth interval, presence of PIH, Presence of PROM, mode of delivery, prolonged labor, antepartum haemorrhage, malpresentation, history of referral, history of hospitalization, and malnutrition were associated with $P < 0.2$ and they were included in the multivariable logistic regression analysis.

In the multiple logistic regression analysis rural residents (AOR = 1.89, CI:1.05-3.39, Neonates of mothers who did not have ANC follow-up during pregnancy (AOR = 4.77, CI:2.13-10.72), women who had less than four ANC follow-ups (AOR =2.49 CI:1.13-5.49), short birth interval (AOR= 4.53, CI:2.32-8.83), mothers with PIH (AOR=2.97, CI:1.36-6.48), and mother with PROM during pregnancy (AOR= 2.94, CI:1.30-6.62) were significantly associated with neonatal near miss (**Table 5**).

Table 1. Socio-Demographic Characteristics of Respondents among neonates of postnatal women in North Wollo Zone public hospitals, Northern Ethiopia, 2022.

Variables	Category	Case frequency (%)	Control frequency (%)	Total frequency (%)
Age in years	Less than 20	36(23.8)	59(19.5)	95(21.0)
	20-34	67(44.4)	181(59.9)	248(54.7)
	>34	48(31.8)	62(20.5)	110(24.3)
Residency	Urban	48(31.8)	166(55.0)	214(47.2)
	Rural	103(68.2)	136(45.0)	239(52.8)
Marital status	With partner	141(93.4)	288(95.4)	429(94.7)
	Without partner	10(6.6)	14(4.6)	24(5.3)
	Housewife	82(54.3)	148(49.0)	230(50.8)
	Governmental employee	33(21.9)	72(23.8)	105(23.2)
Maternal occupation	Merchant	21(13.9)	61(20.2)	82(18.1)
	Daily laborer	9(6)	8(2.6)	17(3.8)
	private employee	6(4)	13(4.3)	19(4.2)
	Cannot read and write	58(38.4)	70(23.2)	128(28.3)
Maternal level of education	Primary education	46(30.5)	82(27.2)	128(28.3)
	Secondary education	18(11.9)	78(25.8)	96(21.2)
	College and above	29(19.2)	72(23.8)	101(22.3)
	Cannot read and write	40(28.4)	80(27.8)	120(27.9)
Husband's level of education N =429	Primary education	44(31.2)	81(28.1)	125(29.1)
	Secondary education	29(20.5)	55(19.1)	84(19.6)
	College and above	28(19.8)	72(25.0)	100(23.3)
Family size	Less than 4	92(60.9)	197(65.2)	289(63.8)
	04-Jul	49(32.5)	92(35.5)	141(31.1)
	Greater than 7	10(6.6)	13(4.3)	23(5.1)

Table 2. Obstetric characteristics of respondents among neonates of postnatal women in North Wollo Zone public hospitals, Northern Ethiopia, 2022.

Variables	Category	Case Frequency (%)	Control frequency (%)	Total frequency (%)
parity	primipara	73(48.3)	130 (43.0)	203(44.8)
	multipara	78(51.7)	172(57.0)	250(55.2)
Birth interval (n=250)	< 2 years	50(64.1)	39(22.7)	89(35.6)
	≥ 2 years	28(35.9)	133(77.3)	161(64.4)
ANC visit	Yes	83(55.0)	226(74.8)	309(68.2)
	No	68(45.0)	76(25.2)	144(31.8)
Number of ANC visits (n=309)	01-Mar	72(86.7)	147(65)	219(70.9)
	≥4	11(13.3)	79(35)	90(29.1)
Supplementation of iron and folic acid	< 100 days	59(39.1)	119(39.4)	178(39.3)
	≥ 100 days	27(17.9)	67(22.2)	94(20.8)
	Not taken	65(43.0)	116(38.4)	181(40.0)
Scanned with ultrasound	Yes	81(53.6)	178(58.9)	259(57.2)
	No	70(46.4)	124(41.1)	194(42.8)
PIH	Yes	32(21.2)	16 (5.3)	48(10.6)
	No	119(78.8)	286(94.7)	405(89.4)
PROM	Yes	29(19.2)	15(5.0)	44(9.7)
	No	122(80.8)	287(95.0)	409(90.3)
GDM	Yes	0	6(2)	6(1.3)
	No	151(100)	296(98)	447(98.7)
Antepartum hemorrhage	Yes	15(9.9)	17(5.6)	32(7.1)
	No	136(90.1)	285(94.4)	421(92.9)
Prolonged labor	Yes	10(6.6)	8(2.6)	18(4.0)
	No	141(93.4)	294(97.4)	435(96.0)
Obstructed labor	Yes	6(4.0)	7(2.3	13(2.9)
	No	145(96.0)	295(97.7)	440(97.1)
CPD	Yes	1(0.7)	4(13)	5(1.1)
	No	150(99.3)	298(98.7)	448(98.9)
Malpresentation	Yes	20(13.2)	19(6.3)	39(8.6)
	No	131(86.8)	283(93.7)	414(91.4)
History of hospitalization	Yes	48(31.8)	68(22.5)	116(25.6)
	No	103(68.2)	234(77.5)	337(74.4)
History of referral	Yes	27(17.9)	28(9.3)	55(12.1)
	No	124(82.1)	274(90.7)	398(87.9)
Gestational age at birth	< 37 completed weeks	10(6.6)	12(4.0)	22(4.9)
	37-41 completed weeks	126(83.4)	253(83.8)	379(83.7)
	≥ 42 completed weeks	15(9.9)	37(12.3)	52(11.5)
Weight of newborn at birth	< 2500gms	19(12.6)	27(8.9)	46(10.2)
	2500gms-4000gms	125(82.8)	259(85.8)	384(84.8)
	≥4000gms	7(4.6)	16(5.3)	23(5.1)
Sex of neonate	male	62(41.1)	151(50)	213(47)
	female	89(58.9)	151(50)	240(53)
Meconium-stained amniotic fluid	Yes	5(3.3)	8(2.4)	13(2.9)
	No	146(96.7)	294(97.6)	440(97.1)

Discussions

This study finding showed that rural residents increased the odds of experiencing NNM 1.89 times. This finding is congruent with a retrospective analysis conducted in Northern Ethiopia [17], Hawassa City Governmental Hospitals (6), and Southern Ethiopia [28]. This might be due to differences in access to health-care services and health-related information between the residences. Furthermore, mothers in rural areas may be less likely to seek medical help which requires improving healthcare delivery at the primary-care level where the majority of women are served. Other reason may be that, most Ethiopian rural areas, the distribution of health facilities is far scattered which could lead to delays in accessing adequate emergency, obstetric, and neonatal health care [29,30].

Table 3. Identified neonatal near-miss among neonates of post-natal women in North Wollo Zone public hospitals, Northern Ethiopia, 2022.

Variables	Category	Case frequency (%)	Control frequency (%)	Total frequency (%)
DM	Yes	3(2.0)	3(1.0)	6(1.3)
	No	148(98.0)	299(99.0)	447(98.7)
Chronic HTN	Yes	3(2.0)	7(2.3)	10(2.2)
	No	148(98.0)	295(97.7)	443(97.8)
Anemia	Yes	18(11.9)	28(9.3)	46(10.2)
	No	133(88.1)	274(90.7)	407(89.8)
Cardiac problem	Yes	1(0.7)	2(0.7	3(0.7)
	No	150(99.3)	300(99.3)	450(99.3)
HIV	Yes	6(4.0)	8(2.6)	14(3.1)
	No	145(96.0)	294(97.4)	439(96.9)
Syphilis	Yes	10(6.6)	14(4.6)	24(5.3)
	No	141(93.4)	288(95.4)	429(94.7)
Presence of malnutrition	Yes	25(16.6)	22(7.3)	47(10.4)
	No	126(83.4)	280(92.7)	406(89.6)
Cigarette smoking	Yes	2(1.3)	1(0.3)	3(0.7)
	No	149(98.7)	301(99.7)	450(99.3)

Table 4. Identified neonatal near-miss among neonates of post-natal women in North Wollo Zone public hospitals, Northern Ethiopia, 2022

Near-miss criteria	Frequency (%)
Cardio-respiratory domain	
Absence of regular breathing	71(47.0%)
respiratory rate > 70 bpm	19(12.6%)
Bradycardia < 80 bpm	26(17.2%)
positive pressure ventilation	40(26.5%)
nasal CPAP	40(26.5%)
Intubation for suctioning	49(32.5%)
APGAR score less than 7 in the fifth minute	63(41.7%)
Sensory and drug-related domains	
Inability to suck within 12 hrs.	30(19.9%)
use of corticosteroid for hypoglycemia	5(3.3%)
Use of a vasoactive drug	4(2.6%)
Neuro-renal domain	
Neural tube defects	5(3.3%)
Recurrent seizures	19(12.6%)
Anuria greater than 6 Hrs.	12(7.9%)
Central cyanosis	15(9.9%)
Hepatic Domain	
Serum bilirubin level > 10 mg/dl within 24 hrs.	21(13.9%)
Jaundice in first 24 hrs.	21(13.9%)
Phototherapy within 24 h)	20(13.2%)
Lab-Investigation Domain	
Hgb <10 g/dl	19(12.6%)
WBC < 4000 cells/mm3	17(11.3%)
Blood glucose level < 40 mg/ dl in 24 hrs.	18(11.9%)
Pragmatic Domain	
Surgery in the first-week	8(5.7)
Gestational age of less than 34 weeks	4(2.6)
Birth weight of less than 1750 gm	8(5.3)
Auxiliary temperature 6–12 hrs. less than 35°C	28(18.5%)

Not having ANC follow-up was a significant factor in having neonates with near miss as pointed out in this study, it increased the odds of neonatal near miss by 4.77. This was congruent with a study conducted in Southeast Brazil [31], Southern Ethiopia [32], and Eastern Ethiopia [33]. This may be because the provision of ANC services has a positive impact through screening for pregnancy problems, assessing risk factors, treating problems that may arise during the antenatal period, providing information to pregnant women, and physically and psychologically preparing for parturition and parenthood [34]. Another reason might be that ANC focuses on educating pregnant women on a range of topics, including well-being, birth preparedness, complication readiness, and breastfeeding, and provides effective interventions for preventing and treating certain conditions, such as anemia and hypertensive disorders of pregnancy, all of which ultimately reduce the occurrence of NNM [35].

In addition, ANC indirectly saves the lives of babies by promoting and establishing good health before childbirth and the early postnatal period and often presents the first contact opportunity for a woman to connect with health services, thus offering an entry point for integrated care, promoting healthy home practices, influencing care-seeking behaviors, and linking women with pregnancy complications to a referral system. Women are more likely to provide a skilled attendants if they have had at least one ANC visit [34,36, 37].

In addition, ANC is used as a platform for additional interventions that have been shown to positively influence maternal and child health status, such as immunization, nutrition programs, breastfeeding, birth spacing counseling, and the Provision of skilful midwife-led ANC has been associated with positive outcomes, including fewer preterm births, fewer fetal losses at any gestation, and high rates of positive experiences reported by women [35].

In this study, not only ANC follow-up but also women who had taken fewer than the minimum required ANC visits (four visits) during their pregnancy increased the odds of neonatal near miss events by 2.5 times. This finding was congruent with a study conducted at a tertiary care hospital in central Gujarat, India [38], a study conducted in different areas of Ethiopia [17,25,39], and a study conducted in Bangalore, India (1), and Brazil [40].

Table 5. Bivariable and Multivariable logistic regression analysis on determinants of neonatal near miss among neonates of post-natal women in North Wollo Zone public hospitals, Northern Ethiopia, 2022.

Variables	category	Case (%)	Control (%)	COR (95%CI)	AOR (95%CI)	p-value
Age of mother	<20	36(23.8)	59(19.5)	1.65(0.99-2.72)	1.45(0.76-2.75)	0.25
	>34	48(31.8)	62(20.5)	2.09(1.31-3.34)	1.23(0.66-2.28)	0.51
	20-34	67(44.4)	181(59.9)	1	1	
	Governmental employee	33(21.9)	72(23.8)	0.80(0.51-1.35)	1.63(0.57-4.65)	0.36
Maternal occupation	merchant	21(13.9)	61(20.2)	0.62(0.35-1.09)	0.95(0.43-2.10)	0.91
	Daily laborer	9(6)	8(2.6)	2.03(1.75-5.46)	1.19(0.35-4.04)	0.77
	private employee	6(4)	13(4.3)	0.83(0.30-2.27)	0.74(0.22-2.51)	0.62
	Housewife	82(54.3)	148(49.0)	1	1	
	Cannot read and write	58(38.4)	70(23.2)	2.05(1.18-3.58)	1.51 (0.45-5.02)	0.49
Maternal level of education	Primary education	46(30.5)	82(27.2)	1.39(0.79-2.44)	1.571 (0.53-4.69)	0.42
	Secondary education	18(11.9)	78(25.8)	0.57(0.29-1.12)	0.93 (0.29-2.93)	0.9
	College and above	29(19.2)	72(23.8)	1	1	
Residency	Rural	103(68.2)	136(45.0)	2.62(1.74-3.95)	1.89(1.05-3.39) *	0.033
	Urban	48(31.8)	166(55.0)	1	1	
ANC visit	No	68(45.0)	76(25.2)	2.44(1.12-3.68)	4.77 (2.13-10.72) *	0.0001
	Yes	83(55.0)	226(74.8)	1	1	
Number of ANC visit	01-Mar	72(47.7)	147(48.7)	3.52(1.76-7.02)	2.49 (1.13-5.49) *	0.023
	≥4 visits	11(7.3)	79(26.2)	1	1	
Birth interval	< 2 years	50(33.1)	39(12.9)	6.09(3.39-10.92)	4.53(2.32-8.83) *	0.0001
	≥2 years	28(18.5)	133(44.0)	1	1	
Presence of PIH	Yes	32(21.2)	16 (5.3)	4.81(2.54-9.09)	2.97 (1.36-6.48) *	0.006
	No	119(78.8)	286(94.7)	1	1	
Presence of PROM	Yes	29(19.2)	15(5.0)	4.55(2.35-8.78)	2.94 (1.30-6.62) *	0.009
	No	122(80.8)	287(95.0)	1	1	
Prolonged labor	Yes	10(6.6)	8(2.6)	2.61(1.01-6.74)	2.22 (0.67-7.31)	0.19
	No	141(93.4)	294(97.4)	1	1	
Antepartum hemorrhage	Yes	15(9.9)	17(5.6)	1.85(1.80-3.81)	1.71 (0.68-4.25)	0.25
	No	136(90.1)	285(94.4)	1	1	
Malpresentation	Yes	20(13.2)	19(6.3)	2.27(1.17-4.40)	1.04 (0.44-2.47)	0.92
	No	131(86.8)	283(93.7)	1	1	
	Instrumental	17(11.3)	43(14.2)	0.97(0.52-1.80)	1.16 (0.54-2.49)	0.69
Mode of delivery	c/s before labor starts	13(8.6)	14(4.6)	2.29(1.03-5.08)	1.12 (0.42-2.97)	0.81
	c/s after labor starts	34(22.5)	30(9.9)	2.80(1.61-4.85)	1.76 (0.84-3.69)	0.13
	SVD	87(57.6)	215(71.2)	1	1	
History of referral	Yes	27(17.9)	28(9.3)	2.13(1.20-3.76)	1.09 (0.49-2.40)	0.82
	No	124(82.1)	274(90.7)	1	1	
History of hospitalization	Yes	48(31.8)	68(22.5)	1.60(1.037-2.48)	1.05 (0.54-2.04)	0.87
	No	103(68.2)	234(77.5)	1	1	
Presence of malnutrition	Yes	25(16.6)	22(7.3)	2.52(1.372-4.65)	1.92 (0.89-4.12)	0.95
	No	126(83.4)	280(92.7)	1	1	

This might be explained by the fact that the more prenatal visits a woman has, the more likely she is to receive the necessary care to carry her pregnancy to term with favorable maternal and perinatal outcomes, and that an incomplete ANC visit leads to insufficient care during pregnancy which affect neonatal health outcomes. At each appointment, the women were checked for high-risk pregnancies as part of the necessary ANC and were either treated or sent to a higher level of care as needed. Inadequate screening and management of high-risk pregnancies may result from fewer ANC visits and higher incidence of NNM.

In this study neonates born to mothers with birth intervals, of less than 24 months had increased the odds of NNM by 4.53 times. This study was similar to those study conducted in Southern Ethiopia [25, 28]. A possible reason may be that maternal nutritional depletion, folate depletion, and women with short birth intervals have no adequate time to recover from the physiological stresses of the preceding pregnancy, which may compromise maternal nutritional status and the ability to support fetal growth, resulting in fetal malnutrition and an increased risk of infection and death during childhood [41, 42]. Another reason might be that women with short birth intervals have a higher risk of PROM, preeclampsia, and babies born from women with short birth intervals may also have a higher chance of being small for gestational age, low birth weight, low APGAR score, anemia and respiratory distress [42-44].

On the other hand, those with a shorter interval between conceptions are more likely to have an unwanted and unplanned pregnancy, and these women may not pay enough attention to their pregnancy or receive essential information, such as dietary counseling and fetal monitoring, and a woman's earlier return to pregnancy may also alter lactation and breastfeeding behavior. This exposes the fetus to a variety of problems that later develop into severe neonatal morbidities (near miss) [42].

According to this study, neonates born to women with PROM were 2.94 times increased likely to have NNM. This is supported by studies conducted at tertiary hospitals in Bengaluru and Bangalore, India [1, 4] and previous studies in different areas of Ethiopia [2, 17, 27]. This may be because early rupture of the membrane frequently leads to preterm labor, respiratory distress, birth asphyxia, early onset neonatal sepsis, pulmonary hypoplasia, cord prolapse, and cord compression [45-47]. Premature membrane rupture has been also linked to an increased risk of neonatal morbidity and mortality due to obstetric problems, including 8% of birth asphyxia,4% of neonatal sepsis,44% of low birth weight,3% of very low birth weight, and 26% NICU admission [48]. Preterm PROM is associated with 1/3rd of premature births and is responsible for neonatal problems resulting from premature births [49-51]. Another reason might be related to complications such as amnionitis and endometritis which put the fetus at a greater risk of developing an overwhelming infection (sepsis) circulating throughout the bloodstream [46].

This finding showed that neonates born to mothers with PIH increased in the odds of NNM by 2.97 times. This result is supported by a study conducted at six public maternity hospitals in Southeast Brazil [31], Bangalore (1), and in different areas of Ethiopia [17, 52]. This might be because hypertension in pregnancy constitutes a major health burden in the obstetric population owing to its effect on uteroplacental insufficiency and vital organ damage, And PIH causes unfavourable perinatal outcomes (Low APGAR score, IUGR, Stillbirth, Preterm birth, birth asphyxia, abortion) [53,54].

Newborn infants with mother PIH, preeclampsia, and eclampsia, have intrauterine growth retardation, prematurity, dysmaturity, necrotizing enter colitis and low birth weight. PIH is one of the major causes of neonatal morbidity and mortality [55]. However, the result of this study result is incongruent with a study conducted in Hawassa City Governmental Hospitals [6]. The reason for this might be methodological (study design) differences.

Strength of the study

This study used validated and standardized neonatal near miss identification criteria developed for developing criteria to reduce misclassification and this study used combined data collection techniques (face-to-face interviews and review of medical records).

Limitation of the study

This study was conducted at a facility, and may not be representative of the general population.

Conclusion

In conclusion, this study identified modifiable predictors of NNM, such as lack having ANC follow-up, lack of full ANC visits, birth interval less than 2 years, rural residency and the presence of obstetric complications such as hypertensive disorder in pregnancy and PROM.

Recommendations

Regional, zonal health bureau and Hospitals should strengthen the implementation of the health system policy, Health professionals should encourage Postpartum family planning to achieve optimal birth spacing, should advise all pregnant mothers to complete all ANC contacts, made aware of Pregnant women the need for regular and frequent ANC contacts and should utilize the opportunity offered by ANC visits particularly for women carrying high-risk pregnancies, Health extension workers should give community education and mobilization about pregnancy related complications and the importance of ANC contacts and researchers should assess the quality of ANC service effect on NNM.

Contributed by

Author's Contributions: All authors contributed to the study conception and AA wrote the proposal, analyzed the data and drafted the manuscript. AW and WG approved the proposal with some revisions, participated in data analysis and revised subsequent drafts of the paper. All authors have read and approved the final manuscript.

Availability of Data and Supporting Material: The datasets used and analyzed during the current study are available from the corresponding author up on reasonable request.

The authors declare no potential conflicts of interest with respect to the research, authorship, or publication of this article.

Ethical consideration: Ethical approval was obtained from the Wollo University College of Medicine and Health Sciences Ethical Review Committee (Ref. No CMHS90/14). Permission was obtained from the Department of Obstetrics and Gynaecology, in each Hospital. To ensure confidentiality, a unique ID number was assigned to each questionnaire to maintain its confidentiality. Participants' privacy and confidentiality were guaranteed prior to data collection. Written consent was obtained from the mothers, and they were informed that participation was voluntary and had the full right to withdraw at any time during the interview process, and they were informed that all the data collected would be used for this study only.

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