Research

Determinants of neonatal near-miss among neonates admitted in Wachemo University Nigist Eleni Mohammed Memorial comprehensive specialized Hospital, Hadiya Zone, Southern Ethiopia: a case-control study

Samuel Kusheta Katama, Robel Demelash Tebeje, Legese Petros Leliso, Melesech Eliso Kalbore, Mengistu Lodebo Funga

Corresponding author: Mengistu Lodebo Funga, Department of Midwifery, Hossana College of Health Sciences, Hossana, Ethiopia. mengestulodebo@gmail.com

Determinants of neonatal near-miss among neonates admitted in Wachemo University Nigist Eleni Mohammed Memorial comprehensive specialized Hospital, Hadiya Zone, Southern Ethiopia: a case-control study

Samuel Kusheta Katama[1], Robel Demelash Tebeje[1], Legese Petros Leliso[1], Melesech Eliso Kalbore[2], Mengistu Lodebo Funga[2,&]

[1]Department of Public Health, Hossana College of Health Sciences, Hossana, Ethiopia, [2]Department of Midwifery, Hossana College of Health Sciences, Hossana, Ethiopia

&Corresponding author

Mengistu Lodebo Funga, Department of Midwifery, Hossana College of Health Sciences, Hossana, Ethiopia

Abstract

Introduction: the neonatal period is the most dangerous time for infant survival, accounting for nearly half of all deaths in children under the age of five. There was scarce evidence about neonatal near-miss (NNM) in Ethiopia. This study attempted to identify determinants of neonatal near-miss in Wachamo University Nigist Eleni Mohamed Memorial Comprehensive Specialized Hospital in Hadiya Zone, Southern Ethiopia. **Methods:** *a facility-based case-control study was carried out from May 1 to Oct 30, 2020. The study included 204 neonates (54 cases and 150 controls), with a 93.6% response rate. Cases were collected sequentially, while controls were chosen using systematic random sampling. The data were analyzed with SPSS version 24, and statistical significance was determined using a multivariable logistic regression model with odds ratios and 95% CI.* **Results:** *about 56% of the cases and 50.7% of the controls were male. The mothers/care givers' mean age was 26.3 (4.7 SD) years in cases and 26.3 (4.2 SD) years in controls. Multivariable analysis showed that antenatal care contacts less than 4 (aOR: 3.28, 95% CI 1.40-7.68; p=0.006), no postnatal care utilization (aOR: 5.45, 95% CI 2.45-12.15; p<0.001), unplanned and unwanted pregnancy type (aOR: 3.53, 95% CI 1.22-10.24; p=0.020), maternal anemia (aOR: 6.71, 95% CI 2.64-17.05; p<0.001), and third delay (aOR: 2.97, 95% CI 1.27-6.92; p=0.012) were associated with neonatal near-miss.* **Conclusion:** *antenatal care contacts less than four, no postnatal care utilization, an unplanned and unwanted pregnancy type, maternal anemia, and third delay were determinants of neonatal near-miss. Therefore, strengthened public health and clinical interventions in these areas must prioritize women with maternal anemia.*

Introduction

Neonatal near-miss cases are newborn infants who exhibit specific severity markers and survive the first neonatal week [1]. The near-miss concept is increasingly being used as a tool to evaluate and improve the quality of care by calculating its indicators in clinical audits [1]. In the case of rarely occurring mortality cases, however, epidemiological analysis to identify its determinant factors for occurrence can be performed. Although the World Health Organization (WHO) has not yet developed a neonatal near-miss approach, the recommended pragmatic criteria adopted by Silva *et al.* and validated by Kale PL *et al.* were used in this study, which is birth weight less than 1500 g, APGAR score less than 7 at 5 minutes of life, and gestational age less than 32 weeks [2,3]. The following management criteria were also confirmed as a proxy for organ dysfunction: parenteral therapeutic antibiotics; nasal continuous positive airway pressure; any intubation within the first 27 days of life; phototherapy within the first 24 hours of life; cardiopulmonary resuscitation; use of vasoactive drugs, anticonvulsants, surfactants, blood products, and steroids for refractory hypoglycemia; and any surgical procedure [4].

The neonatal period is the most dangerous time for infant survival, accounting for nearly half of all deaths in children under the age of five [5]. Neonatal mortality is impeding the continued reduction in under-five mortality [6]. Ninety-nine percent of all children who die during their first four weeks of life are born in the world's least developed regions, particularly South Asia and sub-Saharan Africa [6,7]. Sub-Saharan Africa has the highest neonatal mortality rate, accounting for 38% of global neonatal deaths (34 deaths per 1,000 live births in 2011) [6,8]. Neonatal mortality in Ethiopia fell from 39 to 29 per 1,000 live births between the 2005 and 2016 Ethiopian Demographic and Health Surveys (EDHS), but it has remained constant since the 2016 EDHS and is now 30 per 1,000 live births, according to the 2019 mini EDHS [9].

The number of survivors from a "neonatal near-miss" event is expected to be three to six times higher than the number of neonatal deaths [10].

The number of neonatal near-miss cases per 1000 live births ranged from 21.4 to 85.5 [1-3,11,12]. Assessing neonatal near-miss (NNM) cases provides a comprehensive assessment of risk factors, immediate outcomes, and predictive factors in neonates delivered from mothers with various obstetric complications [12]. Achievement of Sustainable Development Goal Target 3.2 (SDG-3.2), which aims to reduce neonatal mortality in all countries to at least 12 per 1,000 live births by 2030 [13]. Given Ethiopia's current achievements, this will be a challenge. We also need to identify and address risk factors during pregnancy, birth, and the neonatal period. However, there is limited evidence in Ethiopia in this regard. So, this study aimed to identify determinants of neonatal near-miss in Wachamo University Nigist Eleni Mohamed Memorial Comprehensive Specialized Hospital in Hadiya Zone, Southern Ethiopia.

Methods

Study design and setting: a facility-based case-control study was conducted from May 1 to October 30, 2020 at Wachamo University Nigist Eleni Mohamed Memorial Comprehensive Specialized Hospital. The hospital, which was founded in 1983, is the only public tertiary care hospital in Hadiya Zone, serving 3.2 million people in its catchment area, with the goal of promoting the health and well-being of the people of southern Ethiopia. The hospital offers comprehensive emergency obstetric care, as well as a pediatric admission ward and a Neonatal Intensive Care Unit (NICU). The hospital has a 15.9 admission rate and an average hospital stay of 4.2 days [14].

Study population: the study population for cases consisted of live newborns delivered at the study hospital or neonates admitted to the pediatric ward or NICU of the same study hospital and surviving at least one of the conditions listed in the pragmatic criteria set or receiving at least one of the interventions listed in the management criteria set. Live newborns and/or neonates who were delivered at the study hospital with normal birth outcomes or admitted to the pediatric ward for indications other than cases indicated in the pragmatic criteria or received none of the management criteria set were chosen as study populations for controls.

Inclusion criteria for study population

Case ascertainment: for case inclusion, the recommended pragmatic criterion proposed by Silva *et al.* and validated by Kale PL *et al.* was used in this study. As a result, live newborns who were delivered at or admitted to the study hospital and survived at least one of the criteria, namely birth weight less than 1500 g, APGAR score less than 7 at 5 minutes of life, and gestational age less than 32 weeks and also, a proxy for organ dysfunction: parenteral therapeutic antibiotics; nasal continuous positive airway pressure; any intubation during the first 28 days of life; phototherapy within the first 24 hours of life; cardiopulmonary resuscitation; the use of vasoactive drugs, anticonvulsants, surfactants, blood products, and steroids for refractory hypoglycemia; and any surgical procedure were included as cases [2-4].

Controls selection: controls included live newborns delivered at or admitted to the same hospital and ward where cases were identified with normal birth outcomes or admitted for indications other than cases.

Exclusion criteria for study population: the exclusion criteria considered were having records that omitted pertinent information required to declare as a case and having a mother or caregiver who has permanent communication difficulties.

Variables

Dependent variable: neonatal near-miss.

Independent variables

Socio-demographic factors: age, residence, maternal educational level, marital status, maternal occupation, father occupation, father education, monthly income.

Obstetric and reproductive health factors: antenatal care, C/S, abortion, complications at birth, stillbirth, postnatal care, knowledge of danger signs, multiple pregnancies, birth preparedness, FGM, contraception, and maternity waiting home utilization.

Maternal factors: pre-gestational diseases, birth interval, maternal behavior (smoking, alcohol, substances), parity, gravidity, age at index pregnancy, presence of partner, current pregnancy type.

Neonatal-related factors: age, sex, who is caregiver, GA, fetal presentation at birth, and fetal malformations.

Access to health care: mode of referral, 1st delay, 2nd delay (distance to facility, means of transport), 3rd delay.

Measurement of the outcome variable and some explanatory variables: newborns who survived at least one of the pragmatic criteria for NNM or received any of the management criteria were labeled as "Yes" and otherwise "No". The second delay (delay to reach the health facility) was measured in the travel time it took to walk to the facility on foot and it was categorized to ≤ 2 and > 2 hours according to the Ethiopian travel time standard [15]. The first and third delays were measured in hours and/or minutes and the first delay (delay to seek health care) was categorized into ≤ 24 hours and > 24 hours; whereas the third delay (delay to receive care) was categorized as < 1 hour and ≥ 1 hour [16].

Sample size determination: the sample size was estimated using Epi-Info version 7.2.2.6 software for unmatched case-control studies, with the following assumptions: the power of 80%, the confidence level of 95%, and the control-to-case ratio of three (3: 1). The exposure status of controls and the odds ratio for significant determinant factors were obtained from a facility-based study conducted at Injibara general hospital in northwest Ethiopia, with referral linkage versus no referral linkage as one of the main exposure variables for neonatal near-misses that provided the largest sample size [17]. The percent of controls exposed to the stated variable was 62.2 percent, with an odds ratio of 3.23. As a result, a sample size of 218 neonates (55 cases and 163 controls) was calculated, with a 10% non-response rate.

Sampling: all neonatal near-miss cases during the study period were included consecutively, and for each near-miss case, three controls were selected using systematic random sampling, and the interval between every two neonates was taken (k = 541 total deliveries/218 ≈ 2). Patient cards and admission log books were used to identify cases.

Data collection: data were gathered using a pre-tested structured interviewer-administered questionnaire (Cronbach's = 0.74) developed after a thorough review of the literature. The same data collector used face-to-face interviews and client record review techniques to collect data. Depending on the neonate's clinical condition, the interview was held in a private area at admission or later during their stay at the hospital near discharge. The entire data collection process was overseen by a trained general practitioner who worked in the study hospital. The hospital's obstetrics and gynecology ward, pediatrics ward, and neonatal Intensive Care Unit (NICU) were all visited for data collection.

Definitions

Neonatal near-miss: any neonate who nearly died but survived a severe complication that occurred during pregnancy, birth, or within 28 days of extra-uterine life.

Knowledge of pregnancy danger signs: respondents when answering more than half of the knowledge questions were considered to have good knowledge and otherwise poor knowledge.

Birth preparedness: respondents who had at least one of the components of the birth preparedness plan in their current pregnancy were considered to have birth preparedness and otherwise no birth preparedness.

Statistical analysis: each questionnaire was checked for completeness, coded, and entered into Epi-data Version 4.4 before being exported to SPSS for Windows 24 for analysis. The finding was described using frequencies, proportions, and measures of variation. A binary logistic regression model was built. Variables with a p-value of 0.20 in bivariate logistic regression were recruited for the final multivariable logistic regression model. The Hosmer and Lemeshow goodness of fit test (x^2= 7.28, p-value = 0.401) were used to assess model fitness. Statistical significance was determined using odds ratios and 95% confidence intervals, with a p-value of 0.05 considered statistically significant.

Ethical consideration: the study protocol was approved and ethical clearance was obtained from the Hossana College of health sciences, institution review board (IRB) by ref. no HHSC09/4451. Permission was granted from the concerned bodies of the Hospital. Informed assent was obtained from the mother or caregiver for each study subject. Confidentiality of the information was assured by not identifying the names of the study participants.

Results

Socio-demographic and economic characteristics of respondents: a total of 204 study participants (54 cases and 150 controls) were included in the analysis, with a 93.6% response rate. The mean age of the mothers/caregivers was 26.3 (4.7 SD) years for cases and 26.3 (4.2 SD) years for controls. Currently, 98.1% of cases and 98.7% of controls were married. The percentage of cases with rural parents more than doubles that of controls (53.7% VS 26.7%). Mothers with no formal education made up 5.6% of the cases and 4.7% of the controls. A family's median monthly income in cases was $105 (IQR $52 to $184) and $79 (IQR $39 to $131) in controls (Table 1).

Reproductive health and obstetric history of respondents: during their current pregnancy, 98% of case mothers and 98.7% of control mothers received antenatal care (ANC). In terms of ANC contact frequency, case mothers (77.4 %) and control mothers (43.2%) had four ANC contacts. Nearly 13% of case mothers and 48% of control mothers were not informed about the danger signs of pregnancy during their booking visit. As a result, 79.6% of case mothers and 74.7% of control mothers were unaware of pregnancy danger signs. Sixty-three percent of case mothers were prepared for childbirth, compared to 75.3% of control mothers. Nine percent of case mothers and 5.3% of control mothers have multiple pregnancies at some point in their lives. In terms of current C/S, the percentages of mothers of cases (38.9%) and controls (36.0%) were comparable. Prolonged labor was the most common type of complication among both case mothers (33.3%) and controls (34.6 %). In terms of postnatal care, 27.8% of cases and 73.3% of controls used it (Table 2).

Maternal-related factors: the median number of pregnancies among case mothers was three (IQR two to four) and three (IQR two to four) among control mothers. Grand multigravida (> 5 pregnancies) is nearly as common in the case of mothers as it is in control mothers (14.8% VS 14.7%). The median time between previous birth and current pregnancy in years for cases' mothers was 3 (IQR 2 to 4) and 2.5 (IQR 2 to 3) for control mothers. For cases, nearly 30% of the neonates' mothers had an unplanned, but desired index pregnancy, compared to 7.3% for controls. Maternal anemia was found in nearly four out of ten cases (46.3%) and one out of ten controls (13.3%) (Table 3).

Neonatal-related factors: the median age of the neonates' cases in days was 7 (IQR 5 to 13.25), whereas the control neonates' median age was 3 days (IQR 1 to 12). The percentage of neonates with vertex presentation was similar in both cases and controls (85.2% VS 84.0%). Male sex was discovered in 56% of cases and 50.7% of controls (Table 4).

Access to health care: almost half of the cases (46.3%) and controls (45.3%) were referred by another medical facility. Health centers referred both cases (64.0%) and controls (58.8%). Both cases (33.3%) and controls (45.3%) relied heavily on public transportation as their primary mode of transportation. The median time it took cases' mothers to seek medical help was 18 hours (IQR 13.75 to 30), while controls mothers took 19.5 hours (IQR 15 to 30). The median duration of the second delay among case mothers was 3 hours (IQR 1.5 to 6) compared to 3 hours (IQR 2 to 4.5) among control mothers. In some cases, the median duration of the third delay was 30 minutes (IQR 20 to 45) and in controls, it was 20 minutes (IQR 15 to 40) (Table 5).

Determinants of neonatal near-miss: during bivariable analysis, all variables with a p-value of less than 0.20 were entered into multivariable logistic regression analysis. Thus, in the multi-variable analysis, the variables found to be associated with neonatal near-miss in the final model were less than four ANC contacts (aOR: 3.28, 95% CI 1.40-7.68; p=0.006), no PNC utilization (aOR: 5.45, 95% CI 2.45-12.15; p< 0.001), unplanned and unwanted pregnancy type (aOR: 3.53, 95% CI 1.22-10.24; p=0.020), maternal anemia (aOR: 6.71, 95% CI 2.64-17.05; p < 0.001), and third delay (aOR: 2.97, 95% CI 1.27-6.92; p=0.012) (Table 6).

Discussion

This unmatched case-control study was focused on identifying determinants of neonatal near-miss among neonates admitted to Nigist Eleni Mohamed Memorial comprehensive specialized Hospital, Southern Ethiopia. In this study, neonates whose mothers had fewer than four antenatal care contacts were three times more likely to develop neonatal near-misses than neonates whose mothers had four or more antenatal care contacts. This finding was similar to one found in an Ethiopian study of Ambo referral and general hospitals, where less than four antenatal care visits were found to be an obstetric factor associated with neonatal near-miss [18]. According to a multivariate analysis of a prospective study conducted in Northwestern Brazil, having fewer than six prenatal care visits was significantly associated with an increased risk of neonatal near-miss [19]. In studies conducted in the Gamo and Gofa zones of southern Ethiopia, as well as another study from Brazil, no antenatal care follow-up was found to be a factor associated with neonatal near-miss [20,21]. This suggests that women may misunderstand the significance of routine antenatal care contacts in situations where there is no problem. It could also point to questionable quality and quantity of prenatal care consultations provided in previous contacts in Ethiopian health facilities in determining negative outcomes that may discourage women from returning for additional visits. The low socioeconomic status of Ethiopian women may also play a role in the frequency of antenatal care visits. Even though the service was free in public health facilities, women were still responsible for transportation fees and the cost of consulting a senior obstetrician in private health facilities, which may discourage them from returning. As a result, antenatal care programs require additional promotion and quality improvement.

Similarly, neonates who did not receive postnatal care had a risk of developing neonatal near-miss that was more than five times higher than neonates who did receive postnatal care. A DHS further analysis report from Myanmar found that the risk of neonatal death was 9-fold higher among neonates who did not receive any postnatal care compared to neonates who did receive postnatal care from skilled providers, despite the fact that more than 60% of neonates

in the study did not receive any postnatal care [22]. Despite the fact that safe motherhood programs recommend that all women receive a health check within two days of delivery, 33.8% of neonates in Ethiopia received a postnatal check within the first two days of birth [9]. Prompt postnatal care for both the mother and the neonate is essential for treating any complications that arise from the delivery and providing the mother with important information on how to care for herself and her neonate [9]. The findings suggest that improving the use of postnatal care and institutional delivery in integration should be a major focus of public health interventions in order to reduce the incidence of neonatal near-misses.

Furthermore, neonates born to mothers who had an unplanned and unwanted pregnancy had nearly four times the odds of having a neonatal near-miss compared to neonates born to mothers who had a planned and desired pregnancy. Similarly, an unwanted and unplanned current pregnancy type was discovered to be a determinant factor for neonatal near-misses in an Ethiopian study [18]. A similar finding was documented in a study conducted in Douala, Cameroon [23]. The problem is global, affecting women, their families, and society in the developing world, and it can have serious negative health consequences [24]. In Ethiopia, where 41% of currently married women use modern family planning methods [9], Unwanted and unplanned pregnancies may prevent them from paying attention to their pregnancy both prenatally and after birth, when the fetus in the uterus and/or neonate may encounter neonatal near-miss markers. The finding implies that public health experts should pay more attention to the promotion and intervention of family planning programs in order to increase their coverage for the hindrance of the neonatal near-miss.

The study also found that neonates born to mothers with maternal anemia had nearly seven times the odds of having a neonatal near-miss compared to neonates born to mothers who did not have maternal anemia. According to the findings of a Brazilian study, pre-gestational illnesses such as maternal hypertension and maternal syphilis were factors associated with neonatal near-misses [21]. Another study from Brazil found that hypertensive disease was the main variable statistically associated with neonatal near-miss in nulliparous women [25]. Those maternal pre-gestational diseases that are common during pregnancy, such as hypertension and anemia, were associated with fetal complications such as prematurity, low birth weight, and asphyxia at birth in neonates of mothers with such pre-gestational diseases [26] because these complications were neonatal near-miss pragmatic markers. This suggests that focused antenatal care, which is currently being used in Ethiopia, was required for the detection of maternal anemia during pregnancy in order to significantly reduce the incidence of neonatal near-misses.

Furthermore, the odds of neonatal near-miss were three times higher in neonates of mothers who had a third delay in obstetric care compared to neonates of mothers who had timely received obstetric care at the facility. One study conducted in Brazil concluded that delays in obstetric care were associated with an increased risk of neonatal near-miss, including delayed access to health services due to a lack of specialized services and inappropriate patient behavior [27]. If the third delay in receiving good healthcare at a health facility is not properly considered, it will result in a neonatal near-miss. The preceding paragraph discussed the complications of hypertension in pregnancy; for example, a delay in recognizing signs of severity in cases of pre-eclampsia and, as a result, the need to initiate magnesium sulfate would result in those complications [27]. One study from western Tanzania also found that the third delay contributed to neonatal mortality [28]. As a result of the findings, the third delay in maternal care increases the chances of perinatal complications or neonatal near-miss markers, implying that health professionals who provide maternal care should be trained to recognize and

treat obstetric emergencies in a timely manner. The present study had several strengths. It was based on validated Silva *et al.* [2] criteria for NNM cases detection that analyzed the entire neonatal period (0-27 days) and not only the early neonatal period (0-6 days). In addition, this study was based on mothers´ interviews which is important to minimize information bias and increase its validity and completeness than using record review. The nature of studying incident cases is also helpful to minimize recall bias and additionally, the study used hospital controls to make an equivalent degree of recall among cases and controls of the antecedent exposure.

Despite the fact that the current study used the validated pragmatic and management markers developed by Silva *et al.* [2] using two World Health Organization surveys, it has some limitations. Because private health facilities were not included in this study, it is possible that it does not represent neonatal near-miss cases at private facilities. Furthermore, study participants were only followed until hospital discharge, whereas a control neonate who needed to be followed for 28 days after discharge could develop a near-miss and be excluded from the study.

Conclusion

Our study showed that reproductive and obstetric factor such as fewer than four ANC contacts and no postnatal care utilization; maternal factors such as unplanned and unwanted pregnancy type and pre-gestational illnesses; and access factor third delay were all significant predictors of neonatal near-miss in Wachemo University Nigist Eleni Mohammed Memorial comprehensive specialized hospital. As a result, evidence-based clinical and public health intervention programs that specifically target determinant factors to reduce neonatal morbidity and mortality are required, while women with maternal anemia must be more vigilant.

What is known about this topic

- *Neonatal near-miss (NNM) cases provide a comprehensive assessment of risk factors, immediate outcomes, and predictive factors in neonates delivered from mothers with various obstetric complications;*
- *Sub-Saharan Africa has the highest neonatal mortality rate.*

What this study adds

- *Maternal factors such as unplanned and unwanted pregnancy type and pre-gestational illnesses; and access factor third delay were all significant predictors of neonatal near-miss;*
- *Prolonged labor was the most common type of complication among both case mothers and controls;*
- *Antenatal care (ANC) less than 4 contacts, no PNC utilization, unplanned and unwanted pregnancy type, pre-gestational illnesses and third delay are associated with neonatal near-miss.*

Competing interests

The authors declare no competing interests.

Authors' contributions

All authors contributed to the study conception and design. Samuel Kusheta and Robel Demelash had the idea for the article and performed the literature search and statistical analysis, Legesse Petros, Melesech Eliso and Mengistu Lodebo drafted the article, and Samuel Kusheta and Mengistu Lodebo critically revised the work. All the authors have read and agreed to the final manuscript.

Acknowledgments

Tables

Table 1: socio-demographic and economic characteristics of parents/caregivers of neonates admitted to Wachamo University Nigist Eleni Mohamed Memorial Comprehensive Specialized Hospital, Southern Ethiopia, 2020 (n=204)

Table 2: reproductive health and obstetric history of mothers of neonates admitted to Wachamo University Nigist Eleni Mohamed Memorial Comprehensive Specialized Hospital, Southern Ethiopia, 2020 (n=204)

Table 3: maternal factors among neonates admitted to Wachamo University Nigist Eleni Mohamed Memorial Comprehensive Specialized Hospital, Southern Ethiopia, 2020

Table 4: neonatal related-factors among neonates admitted to Wachamo University Nigist Eleni Mohamed Memorial Comprehensive Specialized Hospital, Southern Ethiopia, 2020 (n=204)

Table 5: three delays among mothers of neonates admitted to Wachamo University Nigist Eleni Mohamed Memorial Comprehensive Specialized Hospital, Southern Ethiopia, 2020

Table 6: determinants of neonatal near-miss among neonates admitted to Wachamo University Nigist Eleni Mohammed Memorial Comprehensive Specialized Hospital in Hadiya Zone, Southern Ethiopia, 2020

References

1. Pileggi-Castro CC, Camelo Jr JS, Perdoná GC, Mussi-Pinhata MM, Cecatti JG, Mori R *et al*. Development of criteria for identifying neonatal near-miss cases: analysis of two WHO multicountry cross-sectional studies. BJOG. 2014 Mar;121 Suppl 1: 110-8. **PubMed| Google Scholar**

2. Silva AA, Leite AJ, Lamy ZC, Moreira ME, Gurgel RQ, Cunha AJ *et al*. Neonatal near miss in the Birth in Brazil survey. Cad Saude Publica. 2014 Aug;30 Suppl 1: S1-10. **PubMed| Google Scholar**

3. Kale PL, Jorge M, Laurenti R, Fonseca SC, Silva KSD. Pragmatic criteria of the definition of neonatal near miss: a comparative study. Rev Saude Publica. 2017 Dec 4;51: 111. **PubMed| Google Scholar**

4. Santos J, Cecatti J, Serruya S, Almeida P, Duran P, Mucio D *et al*. Neonatal Near Miss: the need for a standard definition and appropriate criteria and the rationale for a prospective surveillance system. Clinics (Sao Paulo). 2015 Dec;70(12): 820-6. **PubMed| Google Scholar**

5. Santos J, Pileggi-Castro C, Camelo J, Silva AA, Duran P, Serruya S *et al*. Neonatal Near Miss: a systematic review. BMC Pregnancy Childbirth. 2015 Dec 1;15: 320. **PubMed| Google Scholar**

6. Hibstu DT, Ayele TA, Mengesha ZB. Determinants of Neonatal Mortality in Ethiopia: A Case Control Study, 2013. OALib. 2014;01(06): 1-9. **Google Scholar**

7. Lawn JE, Kerber K, Enweronu-Laryea C, Massee Bateman O. Newborn survival in low resource settings-are we delivering? BJOG. 2009 Oct;116 Suppl 1: 49-59. **PubMed| Google Scholar**

8. UNICEF. Levels and Trends in Child Mortality: Estimates Developed by the UN Inter-Agency Group for Child Mortality Estimation. New York, USA. 2018. **Google Scholar**

9. Ethiopian Public Health Institute FMoH. The DHS Program ICF, Rockville, Maryland, USA, Ethiopia Mini Demographic and Health Survey 2019, Key Indicators,. July 2019.

10. UNICEF. **Levels and Trends in Child Mortality. Report 2019**. Accessed March 13, 2023.

11. Pileggi C, Souza JP, Cecatti JG, Faúndes A. Neonatal near miss approach in the 2005 WHO Global Survey Brazil. J Pediatr (Rio J). 2010 Jan-Feb;86(1): 21-6. **PubMed| Google Scholar**

12. Nakimuli A, Mbalinda SN, Nabirye RC, Kakaire O, Nakubulwa S, Osinde MO *et al*. Still births, neonatal deaths and neonatal near miss cases attributable to severe obstetric complications: a prospective cohort study in two referral hospitals in Uganda. BMC Pediatr. 2015 Apr 17;15: 44. **PubMed| Google Scholar**

13. United Nations. Transforming our world: the 2030 agenda for sustainable development, New York: United Nations. 2015. **Google Scholar**

14. Hadiya Zonal Health Department; 2010 E.F.Y. Zonal MCH and nutritional interventions performance report, Hossana (Ethiopia), (unpublished document). August 2018.

15. The World Bank Group and MOH E. Ethiopia: A Country Status Report on Health and Poverty, Volume 2, Main Report. July 2005.

16. Assarag B, Dujardin B, Delamou A, Meski FZ, De Brouwere V. Determinants of MaternalNear-Miss in Morocco: Too Late, Too Far, TooSloppy. PLoS One. 2015 Jan 22;10(1): e0116675. **PubMed| Google Scholar**

17. Gebrehana Belay H, Limenih SK, Wassie TH, Ambie MB. Neonatal Near Miss and Its Associated Factors at Injibara General Hospital, Awi Zone, Northwest Ethiopia, 2019. Exploratory Research and Hypothesis in Medicine. 2020 Apr 27;5(2): 62-9. **Google Scholar**

18. Roga EY, Bacha YD. Determinants of Neonatal Near Miss Among Neonates Admitted to Ambo University Referral Hospital and Ambo General Hospital, Ethiopia, 2019 [Preprint]. Research Square Pediatrics. 2019. **Google Scholar**

19. de Lima TH, Katz L, Kassar SB, Amorim MM. Neonatal near miss determinants at a maternity hospital for high-risk pregnancy in Northeastern Brazil: a prospective study. BMC Pregnancy Childbirth. 2018 Oct 12;18(1): 401. **PubMed| Google Scholar**

20. Mersha A, Bante A, Shibiru S. Factors associated with neonatal near-miss in selected hospitals of Gamo and Gofa zones, southern Ethiopia: nested case-control study. BMC Pregnancy Childbirth. 2019 Dec 21;19(1): 516. **PubMed| Google Scholar**

21. Kale PL, Mello-Jorge MH, Silva KS, Fonseca SC. Neonatal near miss and mortality: factors associated with life-threatening conditions in newborns at six public maternity hospitals in Southeast Brazil. Cad Saude Publica. 2017 May 18;33(4): e00179115. **PubMed| Google Scholar**

22. Ko KZ, Myo MM, MacQuarrie KL. Use of maternal and neonatal health services associated with neonatal death in Myanmar Further analysis of the Myanmar Demographic and Health Survey 2015-16. DHS Further Analysis Report. 2019(125). **Google Scholar**

23. Koum D, Essomba N, Odile N, Ngwe I, Ndanga M, Ndombo PK *et al*. Factors associated with early neonatal morbidity and mortality in an urban district hospital. Int J Latest Res Sci Technol. 2015;5(3): 9-43. **Google Scholar**

24. Klima CS. Unintended pregnancy - Consequences and solutions for a worldwide problem. J Nurse Midwifery. 1998 Nov-Dec;43(6): 483-91. **PubMed│ Google Scholar**

25. Martinelli KG, Gama SG, Almeida AH, Pacheco VE, Santos Neto ET. Advanced maternal age and factors associated with neonatal near miss in nulliparous and multiparous women. Cad Saude Publica. 2019 Nov 28;35(12): e00222218. **PubMed│ Google Scholar**

26. Abalos E CC, Carroli G, Qureshi Z, Widmer M *et al*. Pre-eclampsia, eclampsia and adverse maternal and perinatal outcomes: a secondary analysis of the World Health Organization Multicountry Survey on Maternal and Newborn Health. BJOG. 2014 Mar;121 Suppl 1: 14-24. **PubMed│ Google Scholar**

27. Carvalho OM, Junior AB, Augusto MC, Leite ÁJ, Nobre RA, Bessa OA *et al*. Delays in obstetric care increase the risk of neonatal near-miss morbidity events and death: a case-control study. BMC pregnancy and childbirth. 2020 Dec;20(1): 1-0. **Google Scholar**

28. Mbaruku G VRJ, Kimondo I, Bilango F, Bergstrom S. Perinatal audit using the 3-delays model in western Tanzania. Int J Gynaecol Obstet. 2009 Jul;106(1): 85-8. **PubMed│ Google Scholar**

Table 1: socio-demographic and economic characteristics of parents/caregivers of neonates admitted to Wachamo University Nigist Eleni Mohamed Memorial Comprehensive Specialized Hospital, Southern Ethiopia, 2020 (n=204)

Variable	Category	Neonatal near-miss status		Total (n = 204), frequency (%)
		Yes (n = 54), frequency (%)	No (n = 150), frequency (%)	
Age of respondents	18 - 29 years	42 (77.8)	116 (77.3)	158 (77.5)
	30 - 41 years	12 (22.2)	34 (22.7)	46 (22.5)
Permanent residence	Rural	29 (53.7)	40 (26.7)	69 (33.8)
	Urban	25 (46.3)	110 (73.3)	135 (66.2)
Respondent's marital status	Currently in marriage	53 (98.1)	148 (98.7)	201 (98.5)
	Currently not in marriage	1 (1.9)	2 (1.3)	3 (1.5)
Mother's occupation	Housewife	36 (66.7)	100 (66.7)	136 (66.7)
	Civil servant	9 (16.7)	22 (14.7)	31 (15.2)
	Merchant	7 (13.0)	12 (8.0)	19 (9.3)
	Other (maid, student, daily laborer)	2 (3.8)	16 (10.6)	18 (8.9)
Father's occupation	Farmer	23 (42.6)	26 (17.3)	49 (24.0)
	Civil servant	13 (24.1)	43 (28.7)	56 (27.5)
	Merchant	12 (22.2)	38 (25.3)	50 (24.5)
	Other (driver, student, daily laborer)	6 (11.1)	43 (28.7)	49 (24.0)
Mother's level of education	No formal education	3 (5.6)	7 (4.7)	10 (4.9)
	Primary school (1-8)	23 (42.6)	54 (36.0)	77 (37.7)
	Secondary school (9-12)	16 (29.6)	62 (41.3)	78 (38.2)
	Tertiary or higher (12+)	12 (22.2)	27 (18.0)	39 (19.1)
Father's level of education	No formal education	11 (20.4)	18 (12.0)	29 (14.2)
	Primary school (1-8)	14 (25.9)	31 (20.7)	45 (22.1)
	Secondary school (9-12)	17 (31.5)	57 (38.0)	74 (36.3)
	Tertiary or higher (12+)	12 (22.2)	44 (29.3)	56 (27.5)
Family monthly income	< $88	24 (44.4)	78 (52.0)	102 (50.0)
	> $88	30 (55.6)	72 (48.0)	102 (50.0)

Table 2: reproductive health and obstetric history of mothers of neonates admitted to Wachamo University Nigist Eleni Mohamed Memorial Comprehensive Specialized Hospital, Southern Ethiopia, 2020 (n=204)

Variable	Category	Neonatal near-miss status		
		Yes (n = 54), frequency (%)	No (n = 150), frequency (%)	Total (n = 204), frequency (%)
Female genital mutilation	Yes	38 (70.4)	133 (88.7)	171 (83.8)
	No	16 (29.6)	17 (11.3)	33 (16.2)
Contraceptive use	Yes	33 (61.1)	59 (39.3)	92 (45.1)
	No	21 (38.9)	91 (60.7)	112 (54.9)
Receive antenatal care (ANC) in current pregnancy	Yes	53 (98.1)	148 (98.7)	201 (98.5)
	No	1 (1.9)	2 (1.3)	3 (1.5)
Frequency of ANC n = 201 (53:148)	< 4 times > 4 times	41 (77.4) 12 (22.6)	64 (43.2) 84 (56.8)	105 (52.2) 96 (47.8)
Antenatal admissions in current pregnancy n = 201 (52:149)	Yes	13 (24.5)	8 (5.4)	21 (10.4)
	No	40 (75.5)	140 (94.6)	180 (89.6)
Knowledge of pregnancy danger signs	Poor knowledge	43 (79.6)	112 (74.7)	155 (76.0)
	Good knowledge	11 (20.4)	38 (25.3)	49 (24.0)
Birth preparedness for current delivery	Yes	34 (63.0)	113 (75.3)	147 (72.1)
	No	20 (37.0)	37 (24.7)	57 (27.9)
Is index delivery a multiple pregnancy	Yes	5 (9.3)	8 (5.3)	13 (6.4)
	No	49 (90.7)	142 (94.7)	191 (93.6)
Ever give stillbirth	Yes	3 (5.6)	8 (5.3)	11 (5.4)
	No	51 (94.4)	142 (94.7)	193 (94.6)
Ever experience abortion	Yes	14 (25.9)	8 (5.3)	22 (10.8)
	No	40 (74.1)	142 (94.7)	182 (89.2)
Ever give birth by cesarean section	Yes	9 (16.7)	32 (21.3)	41 (20.1)
	No	45 (83.3)	118 (78.7)	163 (79.9)
Current cesarean section	Yes	21 (38.9)	54 (36.0)	75 (36.8)
	No	33 (61.1)	96 (64.0)	129 (63.2)
Receiving post-natal care (PNC)	Yes	15 (27.8)	110 (73.3)	125 (61.3)
	No	39 (72.2)	40 (26.7)	79 (38.7)

Samuel Kusheta Katama et al. PAMJ-CM - 12(17). 16 Jun 2023. - Page numbers not for citation purposes.

12

Table 3: maternal factors among neonates admitted to Wachamo University Nigist Eleni Mohamed Memorial Comprehensive Specialized Hospital, Southern Ethiopia, 2020

Variable	Category	Neonatal near-miss status		
		Yes (n = 54), frequency (%)	No (n = 150), frequency (%)	Total (n = 204), frequency (%)
Gravidity	Primigravida	20 (37.0)	57 (38.0)	77 (37.7)
	Multigravida	26 (48.1)	71 (47.3)	97 (47.5)
	Grand multigravida	8 (14.8)	22 (14.7)	30 (14.7)
Birth interval n = 127 (34:93)	< 24 months	2 (5.9)	12 (12.9)	14 (11.0)
	> 24 months	32 (94.1)	81 (87.1)	113 (89.0)
Index pregnancy type	Planned and wanted	38 (70.4)	139 (92.7)	177 (86.8)
	Unplanned and unwanted	16 (29.6)	11 (7.3)	27 (13.2)
Mother experienced anemia in index birth	Yes	25 (46.3)	20 (13.3)	45 (22.1)
	No	29 (53.7)	130 (86.7)	159 (77.9)
Mother experienced hypertension in index birth	Yes	5 (9.3)	24 (16.0)	29 (14.2)
	No	49 (90.7)	126 (84.0)	175 (85.8)

Table 4: neonatal related-factors among neonates admitted to Wachamo University Nigist Eleni Mohamed Memorial Comprehensive Specialized Hospital, Southern Ethiopia, 2020 (n=204)

Variable	Category	Neonatal near-miss status		
		Yes (n = 54), frequency (%)	No (n = 150), frequency (%)	Total (n = 204), frequency (%)
Fetal presentation	Vertex	46 (85.2)	126 (84.0)	172 (84.3)
	Non-vertex	8 (14.8)	24 (16.0)	32 (15.7)
Age of the neonate	Early neonate	29 (53.7)	96 (64.0)	125 (61.3)
	Late neonate	25 (46.3)	54 (36.0)	79 (38.7)
Sex of the neonate	Male	30 (55.6)	76 (50.7)	106 (52.0)
	Female	24 (44.4)	74 (49.3)	98 (48.0)
Fetal malformation	Yes	0 (0.0)	11 (7.3)	11 (5.4)
	No	54 (100.0)	139 (92.7)	193 (94.6)

Table 5: three delays among mothers of neonates admitted to Wachamo University Nigist Eleni Mohamed Memorial Comprehensive Specialized Hospital, Southern Ethiopia, 2020

Variable	Category	Neonatal near-miss status		
		Yes (n = 54), frequency (%)	No (n = 150), frequency (%)	Total (n = 204), frequency (%)
First delay	Delayed < 24 hours	37 (68.5)	98 (65.3)	135 (66.2)
	Delayed > 24 hours	17 (31.5)	52 (34.7)	69 (33.8)
Second delay	Delayed < 2 hours	20 (37.0)	52 (34.7)	72 (35.3)
	Delayed > 2 hours	34 (63.0)	98 (65.3)	132 (64.7)
Third delay	Delayed < 30 minutes	23 (42.6)	93 (62.0)	116 (56.9)
	Delayed > 30 minutes	31 (57.4)	57 (38.0)	88 (43.1)

Table 6: determinants of neonatal near-miss among neonates admitted to Wachamo University Nigist Eleni Mohammed Memorial Comprehensive Specialized Hospital in Hadiya Zone, Southern Ethiopia, 2020

Variable	Category	Neonatal near-miss status		COR (95% CI)	AOR (95% CI)	p-value
		Yes (n = 54), No (%)	No (n = 150), No (%)			
Permanent residence	Urban	25 (46.3)	110 (73.3)	1.00	1.00	1
	Rural	29 (53.7)	40 (26.7)	3.19 (1.67, 6.09)	1.98 (0.86, 4.55)	0.107
ANC frequency (n = 201 (53:148))	< 4 contacts	41 (77.4)	64 (43.2)	4.48 (2.18, 9.22)	3.28 (1.40, 7.68)*	0.006
	> 4 contacts	12 (22.6)	84 (56.8)	1.00	1.00	1
Frequently exposed to fire smoke	Yes	19 (35.2)	18 (12.0)	3.98 (1.89, 8.38)	0.89 (0.31, 2.59)	0.837
	No	35 (64.8)	132 (88.0)	1.00	1.00	1
postnatal care (PNC) utilization	Yes	15 (27.8)	110 (73.3)	1.00	1.00	1
	No	39 (72.2)	40 (26.7)	7.15 (3.56, 14.35)	5.45 (2.45, 12.15)**	<0.001
Current pregnancy type	Planned and wanted	38 (70.4)	139 (92.7)	1.00	1.00	1
	Unplanned and unwanted	16 (29.6)	11 (7.3)	5.32 (2.28, 12.41)	3.53 (1.22, 10.24)*	0.020
Maternal anemia	Yes	25 (46.3)	20 (13.3)	5.60 (2.75, 11.43)	6.71 (2.64, 17.05)**	< 0.001
	No	29 (53.7)	130 (86.7)	1.00	1.00	1
Birth preparedness	Yes	34 (63.0)	113 (75.3)	1.00	1.00	1
	No	20 (37.0)	37 (24.7)	1.80 (0.92, 3.49)	0.47 (0.17, 1.30)	0.147
Third delay	< 30 minutes	23 (42.6)	93 (62.0)	1.00	1.00	1
	> 30 minutes	31 (57.4)	57 (38.0)	2.20 (1.17, 4.14)	2.97 (1.27, 6.92)*	0.012

*Statistically significant variables at p-value of < 0.020; **Significant at p-value of < 0.001; ANC: Antenatal care; PNC: Postnatal care; COR: Crude odds ratio; AOR: Adjusted odds ratio; CI: Confidence interval