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ORIGINAL RESEARCH

Magnitude of Neonatal Admission Diagnosis and Associated Factors at Selected Hospitals in Wollo, Northeast Ethiopia

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Background: Neonates are commonly admitted to neonatal intensive care units, and the type(s) of admission determine the outcome of the neonate. Therefore, we sought to assess the magnitude of neonatal admission and associated factors at selected hospitals in Wollo, northeast Ethiopia in 2022.

Methods: A cross-sectional study on 422 admitted mother–neonate pairs was conducted. Data were collected by face-to-face interviews and reviewing patient records and then entered and analyzed using EpiData version 3.1 and Stata version 14, respectively. Binary logistic regression analyses were employed, and $P<0.05$ was considered statistically significant on multivariate analysis.

Results: The prevalence of neonatal sepsis was 53.4% (95% CI 48.5%–58.2%), low birth weight 36.9% (95% CI 32.3%–41.7%), prematurity 24.2% (95% CI 20.3%–28.5%), and hypoglycemia 9.7% (95% CI 7.2%–13%). Urinary tract infection (AOR 2.22, 95% CI 1.13–4.34), history of abortion (AOR 1.95, 95% CI 1.002–3.78), and twin pregnancy (AOR 6.34, 95% CI 1.84–11.83) were associated with low birth weight. Premature rupture of membrane (AOR 2.87 95% CI 1.31–6.28), history of abortion (AOR 2.36, 95% CI 1.20–4.61), and instrumental delivery (AOR 5.25, 95% CI 1.65–16.71) were associated with neonatal sepsis. Male sex (AOR 2.78, 95% CI 1.45–5.34), pregnancy-induced hypertension (AOR 2.73, 95% CI 1.13–6.60), antepartum hemorrhage (AOR 3.24, 95% CI 1.03–10.20), and premature rupture of membrane (AOR 2.77, 95% CI 1.23–6.24) were associated with prematurity.

Conclusion: The prevalence of low birth weight, prematurity, and neonatal sepsis was high, but neonatal hypoglycemia was low. Urinary tract infection, history of abortion, and twin pregnancy were associated with low birth weight. Premature rupture of membrane, history of abortion, and instrumental delivery were associated with neonatal sepsis. Male sex, pregnancy-induced hypertension, antepartum hemorrhage, and premature ruptures of membrane were associated with prematurity.

Keywords: admission diagnosis, discriminant analysis, Ethiopia, neonatal admission, neonate

Background

Millions of babies are born each year, and a significant number of them are admitted to hospitals for various reasons.[1] Neonatal admission generally refers to the admission of a newborn <29 days old to a health facility for medical care.[2] Neonatal intensive care units (NICUs) provide life support to newborns; however, admission to an NICU entails risk for families and their admitted infants, including high costs.[3,4] Admission to the NICU interrupts the mother–infant bonding and establishment of breastfeeding.[5,6] Neonatal mortality and newborn compromise is a major concern in sub-Sahara n Africa, and their rates reflect a nation's socioeconomic status, efficiency, and effectiveness of health-care services.[7] Ethiopia is one of the 10 countries where newborn mortality and morbidity are the highest.[1]

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The reasons for entry into NICUs are the result of different morbidities. Neonatal morbidities include hypothermia, sepsis, prematurity, polycythemia hypoglycemia, meconium aspiration syndrome, perinatal asphyxia, congenital anomaly, and others.[8–10] Developmental delay following neonatal morbidity leads to high health-care costs and intense use of medical resources.[11]

Many of the conditions that lead to early neonatal mortality and morbidity in low-income countries can be avoided with relatively simple and cost-effective interventions like contraception, vaccination of pregnant women, hygienic delivery in a hospital, training health-care workers in resuscitation practices, simplified algorithms that allow for early detection of perinatal infections, and early initiation of breastfeeding and skin-to-skin care.[12]

If not recognized and managed quickly, morbidities can escalate to serious complications, such as impaired vision and movement, learning, or behavior problems, which all have devastating effects on long-term developmental outcome and at severe levels lead to mortality.[11,13] Several strategies have been launched to enhance neonatal survival and promotion of health and well-being, such as essential newborn-care services and reproductive, maternal, newborn, and child health in universal health coverage.[14,15]

Neonatal admission can be influenced by numerous factors: maternal sociodemographic characteristics (age, marital status, residence, educational status, monthly income),[16–18] neonatal characteristics (sex, appearance, pulse, grimace, activity, and respiration [APGAR]),[19–21] Maternal behavioral and medical related conditions (HIV/AIDS, diabetes mellitus, malaria, anemia, alcohol intake status),[22–26] and gynecological and obstetric factors (premature rupture of membrane, prolonged labor, mode of delivery, urinary tract infection, antenatal care).[27–31]

While our country has implemented different policies to mitigate neonatal mortality, it remains tilted. According to the Ethiopian Demographic and Health Survey 2016, neonatal mortality was 29 deaths per 1000 live births, but after 3 years it had declined to 30.[32,33] Ethiopia has undertaken to reduce the number of neonatal deaths from its present level to 12 per 1000 live births. Therefore, this study aimed to assess the magnitude of neonatal admission diagnosis and associated factors at selected hospitals in Wollo, northeast Ethiopia in 2022.

Methods

Study Area, Study Design, and Participants

A hospital-based cross-sectional study was conducted in selected South Wollo and North Wollo hospitals in Amhara Regional State from May 7 to August 10, 2022. Four governmental hospitals were selected according to their case flow after reviewing their 45 days of registration: Dessie Comprehensive Specialized Hospital (DCSH), Woldia Comprehensive Specialized Hospital (WCSH), Kombolcha General Hospital (KGH), and Kobo Primary Hospital (KPH).

Inclusion and Exclusion Criteria

Mother–neonate pairs that were selected by systematic random sampling were included in the study. Mother–neonate pairs who were admitted to NICUs in the selected hospitals were included All neonates who were admitted to NICUs whose mothers were not available were excluded, as shown in Figure 1.

Sample Size and Sampling Procedure

The sample size was calculated by a single-population proportion formula based on the prevalence of neonatal sepsis in Nepal (50%),[34] 95% confidence level, and 5% margin of error. After factoring in a 10% nonresponse rate, the final sample for this study was 422. Among governmental hospitals in North Wollo and South Wollo, four hospitals were selected — DCSH, WCSH, KGH, and KPH — based on case flows after reviewing 45 days of admission. The calculated sample size was proportionately allocated based on the previous number of neonates admitted per 45 days in each hospital. Again, the sampling interval was determined by dividing the average number of neonates admitted per 45 days by the number of cases that were included in the study for each hospital, and then the study participants were selected by systematic random sampling after deciding on the random start randomly for each selected hospital, as illustrated in Figure 2.

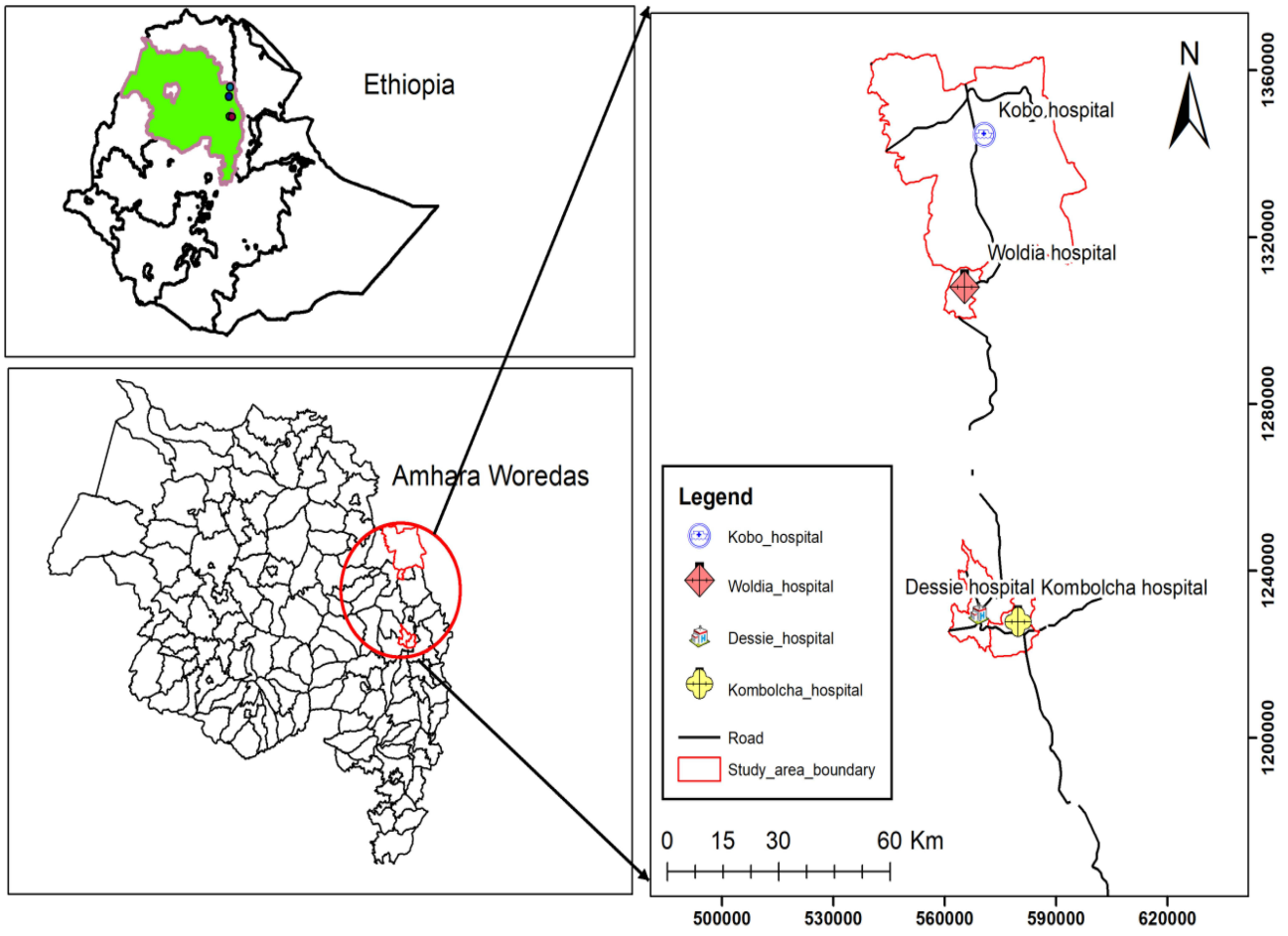

Figure 1 Geographical areas of selected study hospitals.

Data-Collection Procedures and Measurements

Data were collected through an interviewer-administered structured Amharic version questionnaire and data-extraction checklist to extract data from charts developed from previous literature and guidelines. Maternal characteristics were asked about, ensuring the mothers' privacy and confidentiality, after they had finished their contact with the health professional. Some of the questionnaires were also filled by referring to neonate folders/cards, eg, birth weight and APGAR score. Two BSc public health officer supervisors and four BSc nurses who are currently employed in the same health facility were employed as data collectors. Every incomplete questionnaire was sent back to the corresponding data collector for checkup.

Neonatal admission refers to the admission of the newborn <29 days old to a health facility for medical care.[2] Neonates were considered to have sepsis if they had a clinical syndrome of bacteremia with systemic signs and symptoms of infection in the first 4 weeks of life. The neonate may present with any of the systemic manifestations of danger signs: not feeding well, convulsions, drowsy or unconscious, movement only when stimulated or no movement at all, fast breathing [60 breaths/min), grunting, severe inward drawing of chest, raised temperature >38°C, hypothermia <35.5°C, central cyanosis, severe jaundice, severe abdominal distension, or localizing signs of infection. Signs of pneumonia include many or severe skin pustules, bulging fontanel, painful joints, joint swelling, and reduced movement.[35] A neonate is said to be hypoglycemic when blood glucose is <47 mg/dL.[35] A newborn is considered premature when he/she was delivered before a gestational age of 37 weeks (259 days) starting from the last normal menstrual period. For those mothers who did not know their last normal menstrual period, early ultrasound and new Ballard score were employed.[36,37] A neonate is considered to have low birth weight (LBW) at <2500 grams, regardless of gestational age.[36,38]

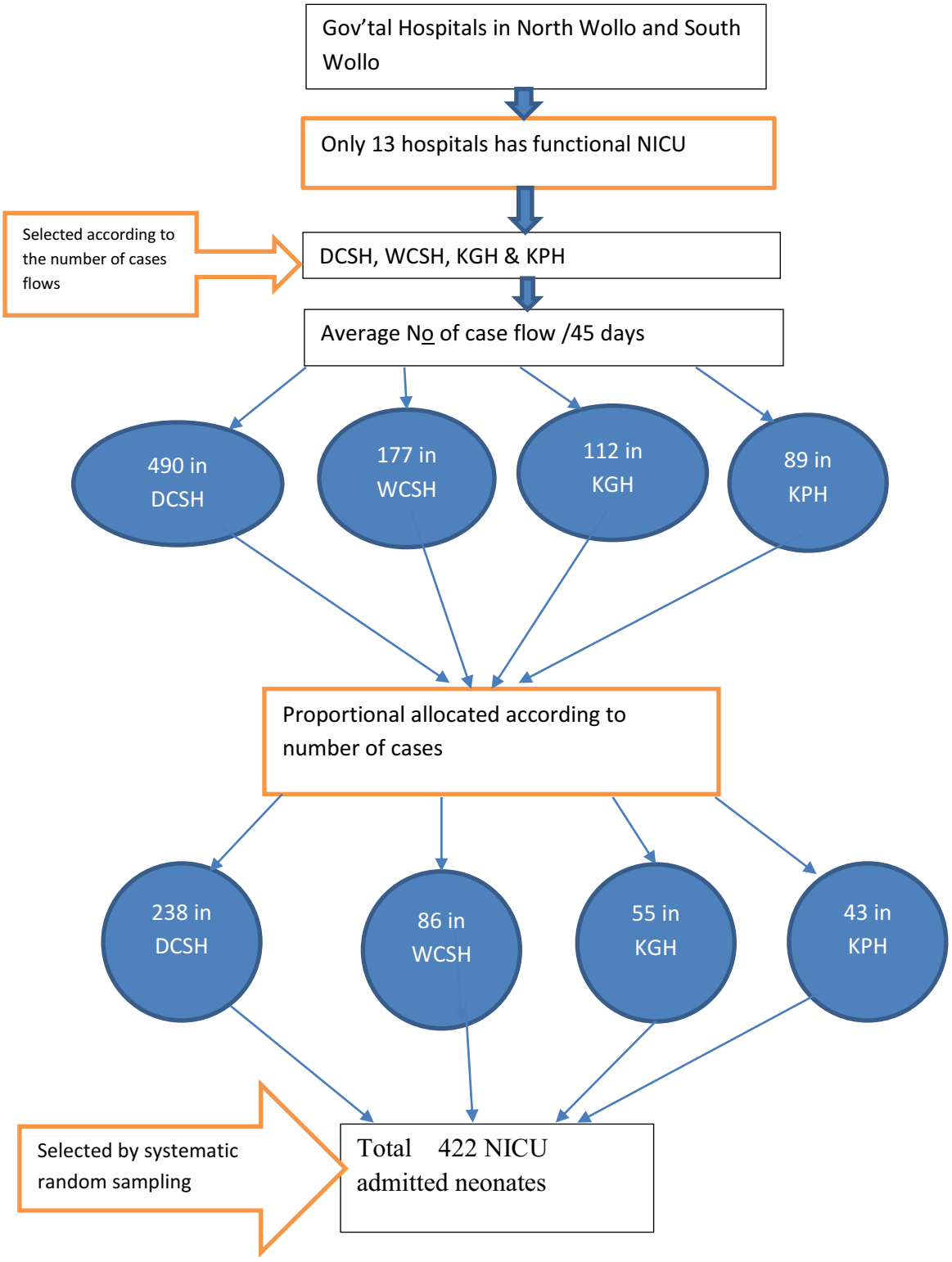

Figure 2 Schematic diagram of sampling procedure.
Abbreviations: NICU, neonatal intensive care unit; DCSH, Dessie Comprehensive Specialized Hospital; WCSH, Woldia Comprehensive Specialized Hospital; KGH, Kombolcha General Hospital; KPH, Kobo Primary Hospital.

Statistical Analysis

The data were entered into EpiData version 3.1 and analyzed using Stata version 14. Descriptive analyses, such as frequencies and percentages, were detemined and discriminant analyses employed to identify the predictors of

neonatal mortality. Then, after bivariate binary logistic regression analysis, those variables with $P<0.25$ were included in a multivariate logistic regression model to control for all possible confounders and to identify predictors of the outcome variable. Hosmer and Lemeshow goodness of fit and standard error were used to check the model goodness of the test and multicollinearity, respectively. In the final model, those variables with $P<0.05$ were considered statistically significant. AORs and 95% CI were estimated to measure the strength and direction of association.

Ethics Approval

This research was carried out in line with the Declaration of Helsinki. Data collection was carried out after obtaining ethics approval from the ethics review committee of Wollo University College of Medicine and Health Sciences (reference CMHS1473/2014). Participants <18 years of age were approved by the ethics committee to provide informed consent on their own behalf. In addition, official letters of cooperation were submitted to each selected hospital. Verbal informed consent was obtained from each respondent prior to enrollment and was considered acceptable and approved by the ethics committee. Each participant was informed about the aim and importance of the study. Anyone who was not willing to participate in the study was not forced to do so and had the full right to refuse or even withdraw from the study. Privacy of the participants and confidentiality of the information they gave was secured at all levels. The information was used only for the purposes of the study.

Results

Sociodemographic Characteristics of Mothers

In sum, 422 mother–neonate pairs participated in this study for a response rate of 100%. The mean age of the mothers was 27±4.76 years, 396 (93.84%) were married, 62.3% (263) resided in an urban setting, 128 (30.33%) had had no formal education, and 206 (48.82%) were housewives, as indicated in Table 1. Of the 422 admitted neonates, 54.74% (231) were female with a mean age of four days, 43.27% (90) had an APGAR score <7 at 1 minute after birth and 70.67% (147) had an APGAR score ≥7 at five minutes after birth. More than half (58.25%, 240) had normal birth weight, as shown in Table 2.

Medical and Behavioral Factors of Mothers

Of the participants, 49 (11.61%) of the mothers were anemic during their pregnancy period while they were pregnant, five mothers were HIV/AIDS-positive, and six were known diabetes mellitus clients. Nineteen (4.5%) drank alcohol and 26 (6.16%) chewed

Table 1 Sociodemographic characteristics of mothers (n=422)

		Frequency	Percentage
Age, years	≤19	16	3.79
	20–34	363	86.02
	≥35	43	10.19
Residence	Urban	263	62.32
	Rural	159	37.68
Marital status	Single	7	1.66
	Married	396	93.84
	Divorced	12	2.84
	Widowed	7	1.66

(*Continued*)

Table 1 (Continued).

		Frequency	Percentage
Education	Cannot read or write	94	22.27
	Can read and write only	34	8.06
	Grade 1–8	130	30.81
	Grade 9–12	82	19.43
	College and above	82	19.43
Occupation	Housewife	206	48.82
	Farmer	85	20.14
	Merchant	54	12.80
	Student	16	3.79
	Employed	61	14.45

Table 2 Characteristics of admitted neonates (n=422)

		Frequency	Percentage
Sex	Male	191	45.26
	Female	231	54.74
APGAR at 1 minute	<7	90	43.27
	>7	118	56.73
APGAR at 5 minutes	<7	61	29.33
	>7	147	70.67
Birth weight	<2500 g	152	36.89
	2500–4000 g	240	58.25
	>4000 g	20	4.85
Aspirate Meconium	Yes	79	18.81
	No	341	81.19

Abbreviations: APGAR, appearance, pulse, grimace, activity, and respiration.

khat during their pregnancy. A total of 406 (96.21%) did not read a newspaper at least once per week, 357 (84.6%) did not listen to the radio at least once per week, and 253 (59.95%) watched TV at least once per week, as illustrated in Table 3.

Obstetric and Gynecological Factors

Of all study participants, 238 (56.4%) mothers were multiparous, 403 (95.5%) mothers had had antenatal care visits at least once, 30 (7.11%) were diagnosed with antepartum hemorrhage (APH), and 70 (17.3%) had premature rupture of membrane. In total, 403 (95.5%) mothers delivered in a health institution and 275 (65.17%) of the neonates were delivered through SVD, 53 (12.05%) via instrumental means (either vacuum or forceps), and the remaining 94 (22.27%) by cesarean section, as indicated in Table 4.

Table 3 Medical and behavioral data of mothers (n=422)

		Frequency	Percentage
HIV/AIDS	Yes	5	1.18
	No	417	98.82
DM	Yes	6	1.42
	No	416	98.58
Anemia	Yes	49	11.61
	No	373	88.39
STI	Yes	419	99.29
	No	3	0.71
Drink alcohol	Yes	19	4.5
	No	403	95.5
Chew khat	Yes	26	6.16
	No	396	93.84
Smoke cigarettes	Yes	2	0.47
	No	420	99.53
Reading newspaper per week	Not at all	406	96.21
	Only once	9	2.13
	Two and above	7	1.66
Listening to radio per week	Not at all	357	84.6
	Only once	40	9.48
	Two and above	25	5.92
Watching TV per week	Not at all	169	40.05
	Only once	7	1.66
	Two and above	246	58.29

Abbreviations: DM, diabetes mellitus; STI, sexually transmitted infection.

Reasons for NICU Admission

The most common reasons for neonatal admission to the NICU were neonatal sepsis (53.8%), LBW (36.9%), hypothermia (32.3%), respiratory distress (26.9%), prematurity (24.2%), asphyxia (20.1%), congenital malformation (12.9%), anemia (12.4%), hypoglycemia (9.7%), jaundice (9.5%), meconium aspiration syndrome (9.2%), and hypoxic–ischemic encephalopathy/encephalopathy (3.2%). Based on discriminant analysis results, LBW (P=0.001), prematurity (P=0.001), neonatal sepsis (P=0.001), and hypoglycemia (P=0.008) were predictors of neonatal mortality.

Factors Associated with NICU Admission

Low Birth Weight

Following bivariate logistic regression, 11 variables with P<0.25 were considered in multivariate analysis. The results showed that urinary tract infection, history of abortion, and birth type were had statistically significant associations with LBW. Those mothers who had had a UTI during pregnancy period were 2.22 times as likely to deliver

Table 4 Obstetric and gynecological factors (n=422)

		Frequency	Percentage
ANC follow-up	No	19	4.5
	Only one	42	9.95
	Only two	114	27.01
	Only three	123	29.15
	Four and above	124	29.38
Birth type	Single	398	94.31
	Twin	24	5.69
Iron with folic acid intake	Yes	351	83.18
	No	71	16.82
PIH	Yes	50	11.85
	No	372	88.15
UTI	Yes	110	26.07
	No	312	73.93
Place of delivery	Health institution	403	95.5
	Home	19	4.5
Mode of delivery	SVD	275	65.17
	Vacuum	51	12.09
	Forceps	2	0.47
	C/S	94	22.27
Presentation	Cephalic	373	88.39
	Breech	21	4.98
	Shoulder	11	2.61
	Compound	17	1.03
PROM	Yes	73	17.3
	No	349	82.7
AF offensive	Yes	11	2.61
	No	411	97.39
APH	Yes	30	7.11
	No	392	92.89
Duration of labor	<12 h	302	71.73
	>12 h	119	28.27
Prelacteal feeding	Yes	2	0.47
	No	420	99.53

(*Continued*)

Table 4 (Continued).

		Frequency	Percentage
Colostrum	Yes	186	44.08
	No	236	55.92
Para	Primipara	184	43.6
	Multipara	238	56.4
Interbirth interval	<33 months	60	25.42
	>33 months	176	74.58
Hx of abortion	Yes	68	28.33
	No	172	71.67
Hx of preterm delivery	Yes	5	2.1
	No	233	97.9
Hx of sepsis	Yes	36	15.13
	No	202	84.87

Abbreviations: ANC, antenatal care; PIH, pregnancy-induced hypertension; UTI, urinary tract infection; SVD, spontaneous vaginal delivery; C/S, cesarean section; PROM, premature rupture of membrane; AF, amniotic fluid; APH, antepartum hemorrhage.

an LBW neonate as mothers who had not. Mothers with a history of abortion were 1.95 times as likely to deliver an LBW neonate as mothers with no history of abortion. Mothers who had a twin gestation were 6.34 times as likely to deliver an LBW neonate as mothers who had a single gestation, as shown in Table 5.

Neonatal Sepsis

Following bivariate logistic regression, 11 variables with $P<0.25$ were considered in multivariatle analysis. The results showed that PROM, history of abortion, and mode of delivery have statistically significant associations with neonatal sepsis. Neonates delivered from PROM mothers were 2.87 times as likely to develop sepsis as their counterparts. Neonates delivered from mothers who had had at least one abortion were 2.36 times as likely to develop sepsis as

Table 5 Bivariate and multivariate binary logistic regression for mothers of low-birth-weight neonates

		LBW		COR (95% CI)	AOR (95% CI)
		Yes	**No**		
Residence	Urban	75	181	1	1
	Rural	77	79	2.35 (1.56–3.56)	1.74(0.83, 3.64)
Marital status	Married	143	243	1	1
	Not married	9	17	0.90(0.39, 2.07)	0.61(0.19, 1.98)
Education	Educated	94	196	1	1
	Not educated	58	64	1.89(1.23, 2.91)	1.23(0.58, 2.62)
Malaria	No	141	251	1	1
	Yes	11	9	2.18(0.88, 5.38)	0.77(0.23, 2.52)

(*Continued*)

Table 5 (Continued).

		LBW		COR (95% CI)	AOR (95% CI)
		Yes	No		
Maternal anemia	No	125	238	1	1
	Yes	27	22	2.34(1.28, 4.27)	1.94(0.75, 4.99)
Drink alcohol	No	140	253	1	1
	Yes	12	7	3.10(1.-19, 8.05)	2.39(0.77, 7.46)
PIH	No	129	233	1	1
	Yes	23	27	1.54(0.85, 2.79)	2.00(0.80, 5.02)
UTI	No	101	201	1	1
	Yes	51	59	1.72(1.10, 2.68)	2.22(1.13, 4.34)*
Hx of abortion	No	27	159	1	1
	Yes	84	152	1.99(1.12, 3.52)	1.95(1.002, 3.78)*
Hx of sepsis	No	65	102	1	1
	Yes	38	30	2.00(0.98, 4.12)	1.55(0.67, 3.59)
Birth type	Twin	18	6	5.69(2.21, 14.66)	6.34(1.84, 11.83)*
	Single	134	254	1	1

Notes: 1, Reference;*$P<0.05$ on multivariate analysis.
Abbreviations: LBW, low birth weight; PIH, pregnancy-induced hypertension; Hx, history.

their counterparts. The odds of developing sepsis for neonates who were delivered via instrumental delivery were 5.25 times those of neonates who were delivered by spontaneous vaginal delivery, as illustrated in Table 6.

Prematurity

Multivariate analysis result showed that sex, pregnancy-induced hypertension (PIH), PROM, and APH, were found to have statistically significant associations with prematurity. Male neonates were 2.78 times as likely to be premature as

Table 6 Bivariate and multivariate binary logistic regression for neonatal sepsis

		Sepsis		COR (95% CI)	AOR (95% CI)
		Yes	No		
Sex	Female	137	94	1.64(1.11, 2.41)	1.07(0.60, 1.91)
	Male	90	101	1	1
Family income	Continuous	227	195	0.99(0.98, 1.09)	0.99(0.98, 1.01)
Occupation	Employed	30	31	1	1
	Not employed	197	164	1.24(0.72, 2.14)	0.87(0.39, 1.93)
Chew khat	Yes	11	15	0.61(0.27, 1.36)	0.34(0.10, 1.25)
	No	216	180	1	1

(*Continued*)

Table 6 (Continued).

		Sepsis		COR (95% CI)	AOR (95% CI)
		Yes	No		
ANC follow-up	Yes	216	187	0.84(0.33, 2.13)	1.83(0.32, 10.47)
	No	11	8	1	1
PROM	Yes	51	22	2.28(1.32, 3.92)	2.87(1.31, 6.28)*
	No	176	173	1	1
Duration of labor	<12 h	170	132	1.45(0.95, 2.22)	1.92(0.89, 4.12)
	>12 h	56	63	1	1
Interbirth interval	>33 months	95	81	1.53(0.85, 2.77)	1.39(0.69, 2.79)
	<33 months	26	34	1	1
Hx of abortion	Yes	44	24	1.93(1.19, 3.11)	2.36(1.20, 4.61)*
	No	79	93	1	1
Hx of sepsis	Yes	24	12	2.08(0.99, 4.39)	1.96(0.85, 4.53)
	No	99	103	1	1
Mode of delivery	SVD	135	140	1	1
	Instrumental	44	9	5.07(2.38, 10.39)	5.25(1.65, 16.71)*
	C/S	48	46	1.08(0.68, 1.73)	1.28(0.64, 2.54)

Notes: 1, Reference;*$P<0.05$ on multivariate analysis.
Abbreviations: ANC, antenatal care; PROM, premature rupture of membrane; APH, antepartum hemorrhage; Hx, history; SVD, spontaneous vaginal delivery; C/S, cesarean section.

female neonates. Mothers who were hypertensive during pregnancy were 2.73 times as likely to deliver a premature baby as their counterparts. Mothers who encountered APH were 3.2 times as likely to have premature neonates as mothers who had no APH. Mothers who had PROM were 2.8 times as likely to deliver premature neonates as their counterparts, as indicated in Table 7.

Table 7 Bivariate and multivariate binary logistic regression for premature birth

		Premature		COR (95% CI)	AOR (95% CI)
		Yes	No		
Sex	Female	42	189	1	1
	Male	60	131	2.06(1.31, 3.24)	2.78(1.45, 5.34)*
Maternal age	Continuous	102	320	1.04(0.99, 1.09)	0.96(0.88, 1.05)
Residence	Rural	50	109	1.86(1.18, 2.92)	1.43(0.47, 4.36)
	Urban	52	211	1	1
Education	Educated	65	229	0.70(0.44, 1.12)	1.18(0.46, 3.00)
	Not educated	37	91	1	1

(*Continued*)

Table 7 (Continued).

		Premature		COR (95% CI)	AOR (95% CI)
		Yes	No		
Watch TV	No	47	122	1.39(0.88, 2.17)	1.42(0.49, 4.16)
	Yes	55	198	1	1
PIH	No	85	287	1	1
	Yes	17	33	1.74(0.92, 3.28)	2.73(1.13, 6.60)*
Maternal anemia	Yes	16	33	1.62(0.85, 3.08)	0.96(0.37, 2.46)
	No	86	287	1	1
UTI	No	65	247	1	1
	Yes	37	73	1.93(1.19, 3.11)	1.81(0.89, 3.71)
PROM	No	80	269	1	1
	Yes	22	51	1.45(0.83, 2.54)	2.77(1.23, 6.24)*
APH	No	84	308	1	1
	Yes	18	22	5.50(2.55, 11.87)	3.24(1.03, 10.20)*
Hx of abortion	No	44	128	1	1
	Yes	25	43	1.69(0.93, 3.08)	1.90(0.95, 3.81)

Notes: 1, Reference;*$P<0.05$ on multivariate analysis.
Abbreviations: PIH, pregnancy-induced abortion; UTI, urinary tract infection; PROM, premature rupture of membrane; APH, antepartum hemorrhage; Hx, history.

Discussion

Our study aimed to identify neonatal admission diagnoses and associated factors at selected hospitals in Wollo, northeast Ethiopia. We identified LBW, prematurity, sepsis, and hypoglycemia as predictors of neonatal mortality by discriminant analysis.

Magnitude of Hypoglycemia

Our study identified hypoglycemia as the admission diagnosis in 9.7% of patients. This is consistent with the reported incidence in Jerusalem, Israel of 12.1%,[39] but is higher than that found in a Ugandan study of 2.2%.[40] This rate is less than that identified in a study conducted at St Paul's Hospital Millennium Medical College, Ethiopia of 25%.[41] These differences may be due to study design, diagnostic modality, patient populations, lactation education and support, and effectiveness in breastfeeding initiation.

Magnitude of Prematurity and Factors Influencing It

Prematurity accounted for 24.2% of admissions in the current study. Male sex, PIH, PROM and APH were significantly associated with prematurity. Our study's prevalence of preterm birth is consistent with a previous study conducted in Pakistan[42] of 27.9%, but is higher than studies conducted in Nigeria (19%)[43] and Jimma (0.2%).[19] It is lower than a previous study conducted in an Addis Ababa tertiary care hospital, St Paul's Hospital Millennium Medical College, which was found to be 36.6%.[44] Differences in reported rates of hospital admissions due to prematurity are likely due to hospital setting and patient population served, as well as newborn assessment using standardized tools, such as Ballard score.[45]

In the current study, we found that male newborns were 2.8 times as likely to be born prematurely as females. This is consistent with studies conducted in France and the Netherlands,[20,21] but differs from a study conducted at Jimma

University Specialized Hospital, Ethiopia.[19] The etiopathogenesis of higher rates of prematurity in male fetuses is multifactorial and could be related to intrauterine growth rates or hormonal differences between sexes.[46,47] Birthing parents who were hypertensive during the pregnancy were 2.7 times as likely to deliver prematurely as those who were not hypertensive. This was also found in a study conducted in China.[48] This may be related to PIH-associated uteroplacental insufficiency and higher rates of placental abruption.[49]

Antepartum hemorrhage was associated with a 3.2-fold increased risk of prematurity. This finding is consistent with studies from Israel and Japan.[50,51] This association is plausible, since profuse, life-threatening vaginal bleeding is an indication for immediate delivery.[52] Premature rupture of membranes in our study was associated with a 2.7-fold increased risk of prematurity, a finding consistent with previous studies conducted in Kenya, Nigeria, and India.[53–55] Whether this is the result of an inflammatory or infectious process is beyond the scope of the present study, but has been reviewed previously.

Magnitude of Low Birth Weight and Factors Influencing It

LBW in our study population was 36.9%. Maternal factors including urinary tract infection and previous abortion as well as mode of delivery were significantly associated with LBW. Rates of LBW were lower than in previous Ethiopian studies conducted in the northwest and southwestern regions: 14.6% and 11.0%, respectively.[56,57] These differences are multifactorial, but may be largely explained by referral patterns to the specialty hospital.

In the current study, the odds of delivering an LBW newborn were significantly higher in twin versus singleton gestation. This finding is in line with studies conducted in sub-Saharan Africa and Nigeria.[58,59] In addition, we found that maternal urinary tract infection during pregnancy was associated with LBW, a finding also noted in studies conducted in the USA, Dumlupinar University in Turkey, and Israel.[60–63]Gravidas with at least one previous abortion doubles the risk risk of LBW. This finding is supported by studies conducted in Denmark, Hawassa, and a systematic review.[64–66] There are many contributing factors that may be related to prior cervical or uterine injury[67] and/or psychological stress, depression, and stigmatization. Those factors could contribute to decreased dietary diversity and higher risk of LBW delivery.[68,69]

Magnitude of Neonatal Sepsis and Factors Influencing It

The incidence of neonatal sepsis in our study population was 53.8%, with PROM, prior abortion, and mode of delivery found to be significantly associated. The prevalence of sepsis correlates with a study conducted in Nepal,[34] but is higher than that found in a Pakistan study[42] and a South African study — 20%, 21%, respectively[9] — and lower than the incidence of 68% found in Gondar.[8] The variance in reported prevalence of neonatal sepsis could be explained by patient characteristics, referral patterns, and infection-control practices.

Premature rupture of membranes was associated with threefold increased odds of developing sepsis, a finding consistent with studies in Jordan, Pakistan, and some studies in Ethiopia.[66,70–73] This finding is plausible given the increased risk of chorioamnionitis and sepsis from ascending infection.[52,74] Prior abortion was associated with double the odds of sepsis, and mode of delivery, particularly with the use of instruments (vacuum or forceps), showed five times the odds of neonatal sepsis. These findings are consistent with previous studies conducted in Sri Lanka, India, and Ethiopia,[75–77] possibly related to fetal scalp/head trauma and less than optimal infection-control measures in place.[78]

Conclusion

Our study of patients admitted to hospitals in Wollo, northeast Ethiopia identified LBW, prematurity, sepsis, and hypoglycemia as predictors of neonatal mortality by discriminant analysis. Half of the newborns were septic on admission and a third were LBW. Future studies should examine interventions to reduce risks of sepsis and LBW.

Strengths and Limitations

Strengths

Predictors of neonatal mortality addressed after implementing discriminant analysis and this research address both maternal and neonatal factors using primary and secondary data. This will be an input for planning and guiding neonatal investments in the catchment area.

Limitations

The results may not be representative of all newborns in South Wollo and North Wollo, due to the study being hospital-based and cross-sectional. Additionally, the subjective nature of diagnosis is another limitation, and lastly it shares the drawbacks of cross-sectional design.

Abbreviations

APGAR, appearance, pulse, grimace, activity, and respiration; APH, antepartum hemorrhage; ANC, antenatal care; DCSH, Dessie Comprehensive Specialized Hospital; DM, diabetes mellitus; GA, gestational age; HIE, hypoxic–ischemic encephalopathy; KPH, Kobo Primary Hospital; KGH, Kombolcha General Hospital; LBW, low birth weight; NICU, neonatal intensive care unit; PIH, pregnancy-induced hypertension; PROM, premature rupture of membrane, SVD, spontaneous vaginal delivery; SDGs, Sustainable Development Goals; UTI, urinary tract infection; WCSH, Woldia Comprehensive Specialized Hospital.

Data Sharing

The datasets used and/or analyzed during this study are available from the corresponding author on reasonable request.

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Disclosure

The authors declare that they have no competing interests.

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