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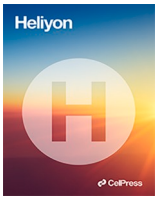

Research article

Neonatal jaundice and associated factors in public hospitals of southern Ethiopia: A multi-center cross-sectional study

Agegnehu Bante [a,*], Muluken Ahmed [b], Nega Degefa [a], Shitaye Shibiru [a], Manaye Yihune [c]

[a] School of Nursing, College of Medicine and Health Sciences, Arba Minch University, Arba Minch, Ethiopia
[b] School of Medicine, College of Medicine and Health Sciences, Arba Minch University, Arba Minch, Ethiopia
[c] School of Public Health, College of Medicine and Health Sciences, Arba Minch University, Arba Minch, Ethiopia

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ABSTRACT

Background: Neonatal jaundice is one of the most prevalent problems, affecting over a million newborns globally every year. It increases the likelihood of hospitalization, lifetime disability, and death, particularly in low and middle-income countries. Despite its impact and diverse risk factors, neonatal jaundice remains underappreciated in developing nations such as Ethiopia. As a result, this study aimed to determine the magnitude and associated factors of jaundice in newborns admitted to public hospitals in south Ethiopia.

Methods: A facility-based cross-sectional study was conducted among 417 newborns from October 1, 2020, to April 30, 2021. The data was collected using pretested interviewer-administered questionnaire and checklist. Jaundice and its severity were assessed using the physician's diagnosis and the Kramer scale. Open data kit tools and Stata version 16.0 were used for data collection and analysis, respectively. Bivariable and multivariable analyses were used to identify factors associated with neonatal jaundice. An odds ratio with a 95 % confidence interval was used to assess the direction and strength of the association.

Results: Out of the newborns, 24.46 % [95 % CI: 20.42–28.88] encountered neonatal jaundice. Being male [AOR: 1.81, 95 % CI: 1.06, 3.12], birth injuries [AOR: 3.01, 95 % CI: 1.27, 7.12], perinatal asphyxia [AOR: 2.10, 95 % CI: 1.18, 3.76], hyaline membrane disease [AOR: 2.16, 95 % CI: 1.16, 4.00], sepsis [AOR: 3.30, (95 % CI: 1.67, 6.54], the combined effect of low birth weight and prematurity [AOR: 1.88, 95 % CI: 1.06, 3.35], and maternal alcohol abuse during pregnancy [AOR: 2.46, 95 % CI: 1.02, 5.94] were significantly associated with neonatal jaundice.

Conclusion: The burden of neonatal jaundice was high in the hospitals studied. Early detection and treatment of neonatal problems, counseling pregnant women to avoid consuming any level of alcohol, strict monitoring of labor and delivery, improving antenatal care utilization, and pre-discharge universal bilirubin screening of newborns are essential to reduce the incidence and complications of jaundice. The findings of this study will be used as input to initiate interventions and conduct further studies.

Abbreviations: AAP, American Academic of Pediatrics; ABE, Acute Bilirubin Encephalopathy; CBE, Chronic Bilirubin Encephalopathy; G6PD, Glucose-6-phosphate dehydrogenase deficiency; HMD, hyaline membrane disease; NICU, Neonatal Intensive Care Unit; SNHB, Severe Neonatal Hyperbilirubinemia; TCB, Transcutaneous Bilirubin; TSB, Total Serum Bilirubin.

* Corresponding author.
E-mail address: agegnehubante@gmail.com (A. Bante).

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1. Introduction

Jaundice, a yellowish discoloration of the skin, sclera, and mucus membrane, is caused by the accumulation of nonpolar, lipid-soluble bilirubin pigment under the skin [1,2]. It can be caused by increased bilirubin production, decreased hepatic absorption, decreased conjugation, impaired excretion, impaired bile flow, or increased enterohepatic circulation. Oxidation-reduction reactions create three-quarters of bilirubin from hemoglobin; the breakdown of myoglobin, cytochromes, and catalase further aids bilirubin synthesis [3]. Jaundice varies by skin tone and body region and progresses in a cephalocaudal direction [4].

Neonatal jaundice occurs in 60 % of term and 80 % of preterm newborns [5]. Around 1.1 million babies worldwide develop hyperbilirubinemia yearly; over 20 million are at risk of hyperbilirubinemia-related complications [6]. Extreme hyperbilirubinemia, in particular, is a risk factor for the death and development of kernicterus in 114,000 and 75,400 newborns, respectively. Around 75 % of these deaths occur in South Asian (SA) and Sub-Saharan African (SSA) countries [7,8]. Furthermore, severe neonatal hyperbilirubinemia (SNHB) and its impact remain the problem of developed nations, and the burden is very high in low and middle-income countries (LMICs) due to delays in effective care [9–11], with 18 % of 134 million live births in 184 countries being at risk of hyperbilirubinemia-related complications [8].

Neonatal jaundice causes hospitalization, lifetime disabilities, and death [7,9]. Bilirubin elevation leads to acute bilirubin encephalopathy (ABE), impairing mental and behavioral status [12]. If left untreated, ABE progresses to chronic bilirubin encephalopathy (CBE) or kernicterus [13,14]. Kernicterus causes cerebral palsy, sensorineural hearing loss, gaze paralysis, and neurodevelopmental retardation [8]; unbound bilirubin also increases the likelihood of auditory toxicity [15,16]. Furthermore, jaundice increases the risk of allergic childhood diseases such as bronchial asthma, acute urticaria, and allergic rhinitis [17].

According to studies from Asian and African countries, neonatal jaundice ranges between 6 and 49 % [9,18–21]. Likewise, studies from Ethiopia reported that neonatal jaundice is between 20.5 and 44.9 % [22–24]. Being male, birth asphyxia, sepsis, prematurity, low birth weight, hypothermia, glucose-6-phosphate dehydrogenase deficiency (G6PD), birth injuries, breastfeeding difficulties, blood group and Rhesus factor incompatibilities, sibling history, vaginal delivery, prolonged labor, and hemolysis are some of the factors associated with neonatal jaundice [22,24–28].

Although it remains challenging, early identification is one of the most effective interventions for reducing the extent and impact of neonatal jaundice [29]. Scholars and the American Academy of Pediatrics (AAP) also proposed universal screening and a follow-up visit within 48–72 h [30–32]. In Ethiopia, the Integrated Management of Newborn and Childhood Illnesses (IMNCI) program recommends a follow-up visit within two days [33]. Furthermore, the Ethiopian government has implemented a variety of interventions to improve newborn survival and to achieve sustainable development goals (SDGs) by 2030 [34].

Neonatal jaundice is one reason for neonatal intensive care unit admission and mortality in LMIC. Although there have been improvements over the past decades, Ethiopia is still one of the countries with the highest neonatal death in the world [35]. According to a recent report, the neonatal mortality rate rise from 29 to 33 per 1000 live births, 35 per 1000 in southern Ethiopia [36,37]. In Ethiopia, few studies address the extent and determinants of neonatal jaundice; however, they were limited to north and central Ethiopia, had a small sample size, and did not intensively address the risk factors for neonatal jaundice. Moreover, none of the studies assessed the severity of jaundice using the Kramer scale, which is a cost-effective and easy method of jaundice screening, particularly for LMICs [10].

As risk factors of neonatal jaundice are heterogenous in LMICs [38], evidence from all corners of the country are imperative to develop national prevention and management protocols and a standard counseling manual for parents. To our knowledge, no research has been conducted on the magnitude and associated factors of neonatal jaundice in southern Ethiopia despite higher neonatal mortality. As a result, this study aimed to determine the magnitude and associated factors of jaundice in newborns admitted to public hospitals in south Ethiopia.

2. Methods and materials

2.1. Study design, setting, and period

A facility-based cross-sectional study was conducted in public hospitals in Gamo, Gofa, and South Omo Zones, southern Ethiopia, from October 1, 2020, to April 30, 2021. There were nine hospitals in these zones, of which four hospitals had neonatal intensive care units (NICUs): Arba Minch general hospital (AMGH), Chencha primary hospital (CPH), Sawula general hospital (SGH), and Jinka general hospital (JGH). AMGH, located in Arba Minch town, is the largest hospital in the Gamo zone, with an annual NICU admission rate of 799 newborns. The hospital had 32 beds, 15 nurses, and three pediatricians that provided newborn care. CPH, located in Chencha town, Gamo zone, served the community with five nurses (including one neonatal nurse), one pediatrician, and 14 beds. The hospital had an annual NICU admission rate of 368. JGH, located in Jinka town, south Omo zone, provides comprehensive neonatal care with 11 nurses, two pediatricians, and 34 beds; around 724 newborns are admitted to the NICU. The SGH, located in Sawla town, Gofa Zone, had 16 beds, five nurses, and one pediatrician to serve the community. The hospital had approximately 568 annual NICU admissions in 2020/2021.

2.2. Study population

All mother-newborn pairs who visited the selected public hospitals were considered as the study population. Neonates admitted to

the neonatal care unit and stayed for at least 48 h were included. Newborns who were readmitted after being interviewed, mothers or guardians with serious health problems, and unable to communicate were excluded.

2.3. Sample size and sampling procedure

The sample size was calculated using a single population proportion formula by considering a 95 % confidence level, 5 % margin of error, and 44.9 % proportion of neonates with hyperbilirubinemia in Black Lion Hospital [22]. After adding a 10 % non-response rate, the final sample size was 420 mother-newborn pairs. The sample was proportionally allocated to the selected hospitals based on the previous year's annual admission rate. Then, a systematic random sampling technique (k = 2) was used to select participants until the required sample size was attained.

2.4. Data collection tool

The data collection tool was adapted from related literature [18,22,24,28]. It had three parts: part one included the socio-demographic characteristics: age, residence, marital status, ethnicity, occupation, education, husband's education and occupation, monthly income, and alcohol abuse. Part two includes the obstetrics characteristics: age at first pregnancy, gravidity, parity, history of stillbirth, neonatal death, and abortion, multiple pregnancies, pregnancy and delivery complications, antepartum hemorrhage, medical illness during pregnancy, antenatal care (ANC) follow-up, time of ANC initiation, medication intake, iron folate, mode of delivery, place of delivery, time of delivery, premature rupture of membrane (PROM), induction/augmentation, duration of labor, and blood group. Part three includes neonate characteristics: sex, age, birth weight, first and fifth-minute Apgar (appearance, pulse, grimace, activity, and respiration) scores, gestational age, breastfeeding difficulty, time of breastfeeding initiation, birth injuries, congenital anomalies, hyaline membrane disease (HMD), birth asphyxia, meconium aspiration syndrome (MAS), seizure, blood group, body temperature, hypoglycemia, sepsis, chest indrawing, level of consciousness, length of hospital stay, jaundice, family history of jaundice, and newborn outcome.

Neonatal jaundice was assessed by the pediatrician's diagnosis and Kramer's scale (visual assessment of the skin in a cephalocaudal direction by blanching the newborn's skin with a finger and observing the underlying skin color with natural light) [10,24]. Although it is not as accurate as total serum bilirubin (TSB) or transcutaneous bilirubin (TcB) for detecting jaundice, the Kramer scale is an easy and cost-effective method [10]. Dionis and colleagues also reported that Kramer's scale has good positive predictive value (PPV) (89.8 %) and specificity (86.1 %) [39]. The Kramer scale had five dermal zones, which were labeled and scored as no jaundice = "0″, jaundiced at head and neck = "1″, upper trunk = "2″, lower trunk and thighs = "3″, arms and lower legs = "4″, and palms and soles = "5" [40].

2.5. Data collectors and data collection procedure

Eight BSc nurses and four MSc professionals were involved as data collectors and supervisors, respectively. The data collection team received training on the study's objectives, data collection methods, and open data kit (ODK) tools. The tool was pretested on 25 mother-newborn pairs at AMGH one month before data collection. A combination of face-to-face interviews, a review of medical records, and direct observation were used for the data assortment. Supervisors and investigators monitored the entire data collection process throughout the study period.

2.6. Operational definitions

Physiological jaundice: neonates with yellowish discoloration (only on the eyes or the face) and infants aged 2–8 days old in term and 2–13 days old in preterm, TSB values of <12 mg/dl in term and <15 mg/dl in preterm newborns, a rise in TSB and a conjugated bilirubin level of 5 mg/dl/24 h and 2 mg/dl/24 h, respectively [24,33].

Pathological jaundice: neonates with yellowish discoloration on the palms or soles or skin and eyes, a baby is ≤ 24 h old or skin and eyes yellow, and when the baby is ≥ eight days in term and ≥14 days old in preterm, along with TSB >12 mg/dl in term and >15 mg/dl in preterm newborns and a rise of TSB and conjugated bilirubin >5 mg/dl/24 h and >2 mg/dl/24 h, respectively [24,33].

Alcohol abuse was assessed using the fast alcohol screening test (FAST), which has four items with scores ranging from 0 to 16, with a score of 3 or higher indicating harmful drinking [41].

Perinatal asphyxia: condition of impaired gas exchange or inadequate blood flow that leads to persistent hypoxemia and hypercarbia, which presented with an Apgar score of <7 at 5 min after delivery [42].

Congenital anomalies: newborns with externally visible defects to any system of the body identified by physical examinations at the time of delivery [43].

Hyaline membrane disease: newborns presented with expiratory grunting, abnormal respiratory rate, nasal flaring, chest wall recessions, or thoracoabdominal asynchrony with or without cyanosis [44].

Premature rupture of membrane: is defined as the disruption of fetal membranes before the onset of labor, characterized by a painless gush of watery fluid out of the vagina [45].

Table 1
Socio-demographic characteristics of participants in public hospitals of southern Ethiopia, 2021 (n = 417).

Variables	Neonatal jaundice		Total, n (%)	X^2
	No, n (%)	Yes, n (%)		
Total	315 (75.54)	102 (24.46)	417 (100.0)	
Age in year				
≤20	35 (11.11)	16 (15.69)	51 (12.23)	0.553
21–24	62 (19.68)	15 (14.71)	77 (18.47)	
25–29	126 (40.0)	38 (37.25)	164 (39.33)	
30–34	71 (22.54)	24 (23.53)	95 (22.78)	
≥35	21 (6.67)	9 (8.82)	30 (7.19)	
Marital status				
Single	10 (3.17)	5 (4.90)	15 (3.60)	0.269
Married	303 (96.19)	95 (93.14)	398 (95.44)	
[a]Other	2 (0.64)	2 (1.96)	4 (0.96)	
Residence				
Urban	133 (42.22)	44 (43.14)	177 (42.45)	0.871
Rural	182 (57.78)	58 (56.86)	240 (57.55)	
Religion				
Orthodox	105 (33.33)	36 (35.29)	141 (33.81)	0.699
Protestant	195 (61.90)	59 (57.84)	254 (60.91)	
Muslim	11 (3.49)	6 (5.88)	17 (4.08)	
[b]Other	4 (1.27)	1 (0.98)	5 (1.20)	
Ethnicity				
Gamo	182 (57.78)	48 (47.06)	230 (55.16)	0.227
Goffa	42 (13.33)	20 (19.61)	62 (14.87)	
South Omo	65 (20.63)	23 (22.55)	88 (21.10)	
[c]Other	26 (8.25)	11 (10.78)	37 (8.87)	
Maternal occupation				
Housewives	249 (79.05)	76 (74.51)	325 (77.94)	0.028
Farmer	2 (0.63)	2 (1.96)	4 (0.96)	
Governmental employee	36 (11.43)	16 (15.69)	52 (12.47)	
Nongovernmental employee	8 (2.54)	0	8 (1.92)	
Merchant	17 (5.40)	3 (2.94)	20 (4.80)	
[d]Other	3 (0.95)	5 (4.90)	8 (1.92)	
Maternal educational status				
Unable to read & write	106 (33.65)	47 (46.08)	153 (36.69)	0.007
Able to read and write	24 (7.62)	2 (1.96)	26 (6.24)	
Primary education	71 (22.54)	25 (24.51)	96 (23.02)	
Secondary education	62 (19.68)	8 (7.84)	70 (16.79)	
College and above	52 (16.51)	20 (19.61)	72 (17.27)	
Husband occupation(n=398)				
Driver	10 (3.30)	5 (5.26)	15 (3.77)	0.589
Farmer	142 (46.86)	48 (50.53)	190 (47.74)	
Governmental employee	76 (25.08)	25 (26.32)	101 (25.38)	
Nongovernmental employee	19 (6.27)	2 (2.11)	21 (5.28)	
Merchant	51 (16.81)	14 (14.74)	65 (16.33)	
[e]Other	5 (1.65)	1 (1.05)	6 (1.51)	
Husband educational status (n=398)				
Unable to read & write	68 (22.44)	35 (36.84)	103 (25.88)	0.013
Able to read and write	32 (10.56)	8 (8.42)	40 (10.05)	
Primary education	62 (20.46)	20 (21.05)	82 (20.60)	
Secondary education	64 (21.12)	8 (8.42)	72 (18.09)	
College and above	77 (25.41)	24 (25.26)	101 (25.38)	
Average monthly income in Ethiopian birr				
<1500 (US$27.39)	48 (15.24)	28 (27.45)	76 (18.23)	0.016
1500-5000 (US$27.39-$91.30)	200 (63.49)	52 (50.98)	252 (60.43)	
>5000 (US$91.30)	67 (21.27)	22 (21.57)	89 (21.34)	
Maternal alcohol abuse				
Yes	23 (7.30)	13 (12.75)	36 (8.63)	0.089
No	292 (92.70)	89 (87.25)	381 (91.37)	
Paternal alcohol abuse (n=398)				
Yes	26 (8.58)	17 (17.89)	43 (10.80)	0.011
No	277 (91.42)	78 (82.11)	355 (89.20)	

[a] separated, divorced.
[b] pagan, seventh Adventist.
[c] derashe, amhara, oromo, guragie, konso, gumaydie wolayita, burgiy hadiya
[d] student; cleaner.
[e] shema sra.

Table 2
Obstetrics characteristics of participants in public hospitals of southern Ethiopia, 2021 (n = 417).

Variables	Neonatal jaundice		Total, n (%)	X^2
	No, n (%)	Yes, n (%)		
Total	315 (75.54)	102 (24.46)	417 (100.0)	
Age at first pregnancy				
≤20	114 (36.19)	39 (38.24)	153 (36.69)	0.886
21–25	136 (43.17)	44 (43.14)	180 (43.17)	
>25	65 (20.63)	19 (18.63)	84 (20.14)	
Gravidity				
Primigravida	125 (39.68)	43 (42.16)	168 (40.29)	0.658
Multigravida	190 (60.32)	59 (57.84)	249 (59.71)	
Parity				
Primipara	141 (44.76)	50 (49.02)	191 (45.80)	0.453
Multipara	174 (55.24)	52 (50.98)	226 (54.20)	
History stillbirth (n=249)				
Yes	9 (4.74)	2 (3.39)	11 (4.42)	0.660
No	181 (95.26)	57 (96.61)	238 (95.58)	
History of neonatal death (n=249)				
Yes	23 (12.11)	5 (8.47)	28 (11.24)	0.441
No	167 (87.89)	54 (91.53)	221 (88.76)	
History of abortion				
Yes	50 (26.32)	14 (23.73)	64 (25.70)	0.691
No	140 (73.68)	45 (76.27)	185 (74.30)	
Experience medical illness during pregnancy				
Yes	51 (16.19)	24 (23.53)	75 (17.99)	0.093
No	264 (83.81)	78 (76.47)	342 (82.01)	
Experience of pregnancy danger signs				
Yes	68 (21.59)	16 (15.69)	84 (20.14)	0.197
No	247 (78.41)	86 (84.31)	333 (79.86)	
Took medication during pregnancy				
Yes	59 (18.73)	7 (6.86)	66 (15.83)	0.004
No	256 (81.27)	95 (93.14)	351 (84.17)	
ANC[a] follow-up				
Didn't attend	5 (1.59)	8 (7.84)	13 (3.12)	0.004
1–3	218 (69.21)	71 (69.61)	289 (69.30)	
≥4	92 (29.21)	23 (22.55)	115 (27.58)	
Time of ANC initiation in weeks				
≤16	100 (32.26)	28 (29.79)	128 (31.68)	0.652
>16	210 (67.74)	66 (70.21)	276 (68.32)	
Iron-folate intake				
Yes	275 (87.30)	86 (84.31)	361 (86.57)	0.442
No	40 (12.70)	16 (15.69)	56 (13.43)	
Labor and delivery complications				
Yes	105 (33.33)	44 (43.14)	149 (35.73)	0.073
No	210 (66.67)	58 (56.86)	268 (64.27)	
Duration of labor in hours				
≤12	197 (62.54)	67 (65.69)	264 (63.31)	0.567
>12	118 (37.46)	35 (34.31)	153 (36.69)	
Labor induction/augmentation				
Yes	39 (12.38)	14 (13.73)	53 (12.71)	0.723
No	276 (87.62)	88 (86.27)	364 (87.29)	
Mode of delivery				
SVD[b]	257 (81.59)	81 (79.41)	338 (81.06)	0.524
Instrument assisted	11 (3.49)	2 (1.96)	13 (3.12)	
CS[c]	47 (14.92)	19 (18.63)	66 (15.83)	
Time of delivery				
Day	159 (50.48)	53 (51.96)	212 (50.84)	0.794
Night	156 (49.52)	49 (48.04)	205 (49.16)	
Twin pregnancy				
Yes	18 (5.71)	10 (9.80)	28 (6.71)	
No	297 (94.29)	92 (90.20)	389 (93.29)	
Place of delivery				
Hospital	219 (69.52)	68 (66.67)	287 (68.82)	0.984
Health center	73 (23.17)	26 (25.49)	99 (23.74)	
Home	23 (7.30)	8 (7.84)	31 (7.43)	
Premature rupture of membrane				
Yes	40 (12.70)	16 (15.69)	56 (13.43)	0.442
No	275 (87.30)	86 (84.31)	361 (86.57)	
Duration of labor in hours				
≤12	197 (62.54)	67 (65.69)	264 (63.31)	0.567

(*continued on next page*)

Table 2 (*continued*)

Variables	Neonatal jaundice		Total, n (%)	X^2
	No, n (%)	Yes, n (%)		
>12	118 (37.46)	35 (34.31)	153 (36.69)	
Maternal blood type				
A	65 (20.63)	23 (22.55)	88 (21.10)	0.155
B	51 (16.19)	14 (13.73)	65 (15.59)	
AB	21 (6.67)	7 (6.86)	28 (6.71)	
O	77 (24.44)	36 (35.29)	113 (27.10)	
Unknown	101 (32.06)	22 (21.57)	123 (29.50)	

[a] antenatal care.
[b] spontaneous vaginal delivery.
[c] cesarean section.

2.7. Data analysis

The data set was downloaded as an Excel file from the ODK aggregate server and imported into Stata version 16.0 for analysis. Descriptive statistical analyses such as mean, standard deviation, and simple frequencies were used to describe participants' characteristics. Explanatory variables with a p-value of ≤ 0.25 in the bivariable analysis were included in the multivariable analysis. The Hosmer-Lemeshow test and Spearman's correlation were used to assess the model's goodness of fit and multicollinearity. An odds ratio with a 95 % CI was used to identify factors associated with neonatal jaundice. Statistical significance was declared at a P-value of <0.05.

2.8. Ethical considerations

The Institutional Review Board (IRB) of Arba Minch University, College of Medicine and Health Sciences, approved the study with a protocol number of IRB/136/12. A permission letter was obtained from each of the hospital administrators. Moreover, before the commencement of the data collection, voluntary informed written consent was secured from the mother/guardians after explaining the purpose of the study. Participants were informed about the right to declare whether they would participate and to withdraw from the study at any time without any loss. Confidentiality of the information gathered from each study participant was secured by using code numbers.

3. Results

3.1. Socio-demographic characteristics

This study included 417 mother-neonate pairs, with a response rate of 99.3 %. AMGH, CPH, SGH, and JGH were represented by 189, 53, 66, and 109 participants, respectively. The mean age of the mothers was 26.8 (SD $\pm$ 4.7) years. Two-fifths (39.33 %) of the mothers were between the ages of 25 and 29, married (95.44 %), and rural dwellers (57.55 %). Three-fifths (60.91 %) were protestant followers, and majority (77.94 %) were housewives. In terms of educational attainment, 153 (36.69 %) couldn't read and write, while 72 (17.27 %) attended college or higher education. Thirty-six (8.63 %) of the mothers had a history of alcohol abuse during pregnancy (Table 1).

3.2. Obstetrics characteristics

One-third (36.69 %) became pregnant for the first time before twenty years of age, and 59.71 % were multigravida. Only 115 (27.58 %) participants had four or more ANC visits for the current pregnancy, and 361 (86.57 %) took iron-folate supplements. Among the participants, 75 (17.99 %), 84 (20.14 %), and 149 (35.73 %) experienced medical illness, pregnancy danger signs, and labor and delivery difficulties, respectively. Majority of the participants (81.06 %) were delivered through spontaneous vaginal delivery. In terms of blood types, 88 (21.10 %) and 113 (27.10 %) had blood group A and O, respectively (**Table 2**). Furthermore, ABO and Rh incompatibility were found in 3.84 % and 2.16 %, respectively.

3.3. Newborn characteristics

The mean age of the newborns at admission was 3.6 (SD: 5.4) days; the mean birthweight was 2794.6 (SD: 907.7) grams. Among the newborns, 239 (57.31 %) were male, and 125 (29.98 %) were born prematurely. The first-minute Apgar score was less than seven for 300 (71.94 %) newborns. Furthermore, 291 (69.78 %), 118 (28.30 %), 78 (18.71 %), and 152 (36.45 %) of newborns experienced sepsis, birth asphyxia, HMD, and breastfeeding difficulties, respectively (**Table 3**).

Table 3
Characteristics of neonates in public hospitals of Southern Ethiopia, 2021 (n = 417).

Variables	Neonatal jaundice		Total, n (%)	X^2
	No, n (%)	Yes, n (%)		
Total	315 (75.54)	102 (24.46)	417 (100.0)	
Sex				
Male	167 (53.02)	72 (70.59)	239 (57.31)	0.002
Female	148 (46.98)	30 (29.41)	178 (42.69)	
Birthweight in gram				
<1500	17 (5.40)	10 (9.80)	27 (6.47)	0.041
1500–2499	86 (27.30)	39 (38.24)	125 (29.98)	
2500–3999	184 (58.41)	46 (45.10)	230 (55.16)	
≥4000	28 (8.89)	7 (6.86)	35 (8.39)	
Gestational age in weeks				
<37	86 (27.30)	39 (38.24)	125 (29.98)	0.076
37–41^{+6}	215 (68.25)	61 (59.80)	276 (66.19)	
≥42	14 (4.44)	2 (1.96)	16 (3.84)	
Newborn blood group				
A	38 (12.06)	16 (15.69)	54 (12.95)	<0.001
B	36 (11.43)	19 (18.63)	55 (13.19)	
AB	10 (3.17)	4 (3.92)	14 (3.36)	
O	46 (14.60)	36 (35.29)	82 (19.66)	
Not recorded	185 (58.73)	27 (26.47)	212 (50.84)	
First-minute Apgar[a] score				
<7	216 (68.57)	84 (82.35)	300 (71.94)	0.007
≥7	99 (31.43)	18 (17.65)	117 (28.06)	
Encounter birth injuries				
Yes	18 (5.71)	20 (19.61)	38 (9.11)	<0.001
No	297 (94.29)	82 (80.39)	379 (90.89)	
Temperature in degree cellicious				
<36.5	129 (40.95)	51 (50.0)	180 (43.17)	0.112
36.5–37.5	123 (39.05)	39 (38.24)	162 (38.85)	
>37.5	63 (20.0)	12 (11.76)	75 (17.99)	
Family history of jaundice				
Yes	0	18 (17.65)	18 (4.32)	<0.001
No	315 (100.0)	84 (82.35)	399 (95.68)	
Sepsis				
Yes	206 (65.40)	85 (83.33)	291 (69.78)	0.001
No	109 (34.60)	17 (16.67)	126 (30.22)	
Seizure				
Yes	17 (5.40)	4 (3.92)	21 (5.04)	0.554
No	298 (94.60)	98 (96.08)	396 (94.96)	
Hypoglycemia				
Yes	10 (3.17)	4 (3.92)	14 (3.36)	0.716
No	305 (96.83)	98 (96.08)	403 (96.64)	
Perinatal asphyxia				
Yes	78 (24.76)	40 (39.22)	118 (28.30)	0.005
No	237 (75.24)	62 (60.78)	299 (71.70)	
Meconium aspiration syndrome				
Yes	34 (10.79)	18 (17.65)	52 (12.47)	0.069
No	281 (89.21)	84 (82.35)	365 (87.53)	
Hyaline membrane disease				
Yes	50 (15.87)	28 (27.45)	78 (18.71)	0.009
No	265 (84.13)	74 (72.55)	339 (81.29)	
Chest indrawing				
Yes	44 (13.97)	28 (27.45)	72 (17.27)	0.002
No	271 (86.03)	74 (72.55)	345 (82.73)	
Congenital malformation				
Yes	8 (2.54)	3 (2.94)	11 (2.64)	0.826
No	307 (97.46)	99 (97.06)	406 (97.36)	
Breastfeeding difficulties				
Yes	103 (32.70)	49 (48.04)	152 (36.45)	0.005
No	212 (67.30)	53 (51.96)	265 (63.55)	
Initiate breastfeeding within 1 h after delivery				
Yes	149 (47.30)	61 (59.80)	210 (50.36)	0.028
No	166 (52.70)	41 (40.20)	207 (49.64)	
Level of consciousness				
Alert	122 (38.73)	38 (37.25)	160 (38.37)	0.261
Lethargic	169 (53.65)	56 (54.90)	225 (53.96)	
Stupor	2 (0.63)	3 (2.94)	5 (1.20)	
Coma	22 (6.98)	5 (4.90)	27 (6.47)	

(*continued on next page*)

Table 3 (*continued*)

Variables	Neonatal jaundice		Total, n (%)	X^2
	No, n (%)	Yes, n (%)		
Length of hospital stay				
<5	84 (26.67)	20 (19.61)	104 (24.94)	0.297
5–10	174 (55.24)	59 (57.84)	233 (55.88)	
>10	57 (18.10)	23 (22.55)	80 (19.18)	
Newborn outcome				
Improved and discharged	264 (83.81)	83 (81.37)	347 (83.21)	0.686
Referred	10 (3.17)	4 (3.92)	14 (3.36)	
Died	28 (8.89)	8 (7.84)	36 (8.63)	
Self-discharge	13 (4.13)	7 (6.86)	20 (4.80)	

[a] appearance, pulse, grimace, activity, respiration.

3.4. Magnitude of neonatal jaundice

Overall, 24.46 % [95 % CI: 20.42, 28.88] newborns experienced neonatal jaundice; of these, 65 (63.73 %) developed within the first 24 h, 15 (14.71 %) encountered bilirubin encephalopathy, and 85 (83.33 %) developed yellowish discoloration up to the level of the upper trunk (Fig. 1). JGH had the highest prevalence (28.44 %), while CPH had the lowest (16.98 %) (Fig. 2).

3.5. Factors associated with neonatal jaundice

In the multivariable analysis, sex, birth injuries, birth asphyxia, HMD, sepsis, the combined effect of LBW and prematurity, and maternal alcohol abuse were significantly associated with neonatal jaundice. The odds of neonatal jaundice were 1.81 times (AOR: 1.81, 95 % CI: 1.06, 3.12) higher among male neonates. The odds of neonatal jaundice were three times (AOR: 3.01, 95 % CI: 1.27, 7.12) higher among neonates with birth injuries than newborns who did not experience birth injuries. Neonatal jaundice was 2.1 times higher (AOR: 2.10, 95 % CI: 1.18, 3.76) among neonates with birth asphyxia than their counterparts. The odds of neonatal jaundice were 2.16 times (AOR: 2.16, 95 % CI: 1.16, 4.00) and 3.30 times (AOR: 3.30, (95 % CI: 1.67, 6.54) higher among neonates with HMD and sepsis, respectively. The odds of neonatal jaundice were 1.88 times (AOR: 1.88, 95 % CI: 1.06, 3.35) higher among neonates with LBW and prematurity compared to average birth weight and term counterparts. Furthermore, maternal alcohol abuse during pregnancy increases the odds of neonatal jaundice by 2.46 times (AOR: 2.46, 95 % CI: 1.02, 5.94) **(Table 4)**.

4. Discussion

Neonatal jaundice is a common clinical condition, particularly in SA and SSA countries [5,6,46,47]. In the current study, nearly one-quarter of the neonates experienced jaundice. Sex, birth injuries, birth asphyxia, HMD, sepsis, the cumulative effect of LBW and prematurity, and alcohol abuse during pregnancy were significantly associated with neonatal jaundice.

In this study, 24.46 % (95 % CI: 20.42–28.88) of neonates encountered jaundice. This finding is in line with the studies conducted in Uganda (22.7 %) [46], Croatia (24.8 %) [48], and southwest Oromia, Ethiopia (20.5 %) [23]. However, it is lower than the studies conducted in south Nepal (55.8 %) [18], Myanmar governmental hospitals (46.0 %) [9], Iran (70.0 %) [49], Thailand (53 %) [26], Taiwan University Hospital (30.5 %) [50], Taiwan (33.5 %) [51], South Africa (55.2 %) [52], Southeast Nigeria (35.0 %) [20], Mekelle (37.3 %) [24] and Black Lion Specialized Hospital, Ethiopia (44.9 %) [22]. On the other hand, this finding is higher than the studies

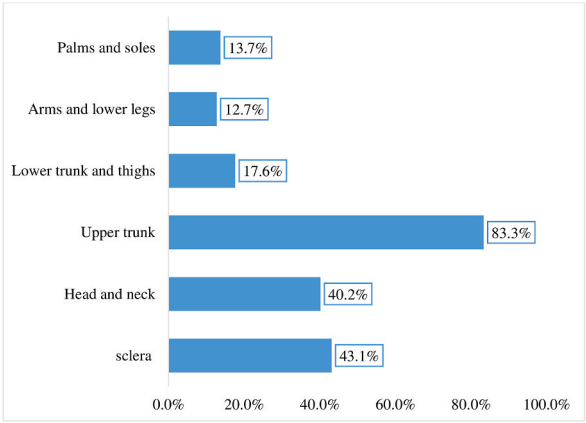

Fig. 1. Level of dermal staining based on the Kramer's scale, 2021 (n = 102).

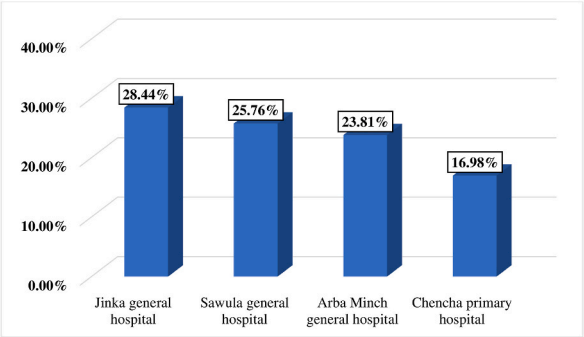

Fig. 2. Prevalence of neonatal jaundice in selected public hospitals in southern Ethiopia.

conducted in India (10.3–13.0 %) [32,53,54], Bangladesh (15.7 %) [55], Iran (15.0 %) [19], Nigeria (17.9 %) [5] and Egypt (16 %) [47]. These disparities could be due to differences in measurement tools; some studies determine jaundice using the TSB level, which is an accurate method to detect even in asymptomatic patients. It could also be due to the study's setting, the quality of perinatal care, or the participants' socioeconomic status. Health facilities that care for newborns should have at least a protocol for visual assessment of jaundice. Moreover, improving health professionals' ability to detect jaundice in a cephalocaudal direction is critical. Furthermore, pre-discharge risk assessment and follow-up visits can effectively reduce the incidence and complications of jaundice.

In this study, male neonates had a higher risk of neonatal jaundice than female neonates. This finding is in agreement with previous studies conducted in Ethiopia [22,24,27,28], Nigeria [5], and Nepal [18]. On the other hand, the survey conducted in Croatia [48] stated that sex has no significant difference in the occurrence of jaundice. The possible explanation is that the ability of the male liver to convert unconjugated to conjugated bilirubin is relatively low, so bilirubin formed as a result of high red blood cell turnover is not effectively removed from the blood. Furthermore, males have higher bilirubin levels and are affected by G6PD deficiency, which leads to bilirubin encephalopathy [56].

Our study demonstrated that birth injuries triple the risk of neonatal jaundice. This finding is concurrent with previous studies that showed cephalhematoma causes hyperbilirubinemia [25,28,57]. The possible explanation is that extracranial injuries (cephalhematoma and subgaleal hemorrhage) lead to red blood cell breakdown, resulting in jaundice. Moreover, birth injuries cause various long-term impairments. Hence, healthcare providers must closely monitor labor and delivery to prevent birth injuries and related complications.

In our study, neonates with birth asphyxia had a higher risk of neonatal jaundice than their counterparts. This finding is congruent with studies conducted in Ethiopia and Nigeria [5,27,28,58]. The reason could be due to the effect of birth asphyxia on the liver, which disrupts bilirubin metabolism. Furthermore, birth asphyxia results in hypoxic-ischemic encephalopathy, which increases bilirubin entry into brain cells and leads to kernicterus [8]. In Ethiopia, birth asphyxia is the second leading cause of neonatal mortality, next to prematurity. Thus, strict labor monitoring using a partograph is mandatory to reduce its occurrence and complications.

Our study demonstrated that HMD doubles the risk of neonatal jaundice. As HMD is a common problem of prematurity, previous studies revealed that preterm delivery is an independent predictor of neonatal jaundice [5,26]. It could be because HMD causes lung problems such as pneumomediastinum, pneumothorax, pneumopericardium, and pulmonary interstitial emphysema. These problems interfere with breathing and cause birth asphyxia, which causes organ dysfunction and inhibits bilirubin metabolism. Improving the quality of ANC and giving corticosteroids before delivery is critical to reducing the incidence and squeal of HMD.

In this study, the odds of neonatal jaundice were three times higher among neonates with sepsis. This finding is supported by studies conducted in Ethiopia [24,27,28] and Nigeria [5,20]. The possible explanation is that infection contributes to the rapid breakdown of red blood cells. In addition, the newborn's immature liver cannot remove bilirubin quickly enough, resulting in an excess of bilirubin due to increased red blood cell production and faster breakdown. Early detection and treatment, as well as prophylaxis during pregnancy in the presence of PROM and maternal temperature elevation, are critical for preventing complications of sepsis, including jaundice.

In this study, the combined effect of LBW and prematurity doubles the risk of neonatal jaundice. Although previous studies did not examine the cumulative impact of LBW [5,27,28,58] and prematurity [5,20], studies have consistently reported that LBW and preterm newborns are at a higher risk of developing jaundice. Early initiation and complete utilization of ANC reduce the risk of LBW, preterm delivery, and various other adverse pregnancy outcomes. However, in the current study, only 31.7 % and 27.6 % of participants initiated on time and completed ANC follow-ups, respectively. As a result, healthcare providers and health extension workers, as well as the government, should place a high priority on improving the quality and coverage of ANC.

According to our findings, maternal alcohol abuse during pregnancy increases the risk of neonatal jaundice. Though we couldn't find a recent study that found a consistent or contradictory result, drinking alcohol during pregnancy is associated with many adverse pregnancy outcomes, including prematurity and LBW, common risk factors for neonatal jaundice [59]. Because alcohol crosses the placenta and negatively affects the fetus and the mother, thus, women should be advised not to consume any amount of alcohol during pregnancy.

The findings are crucial for neonatal care professionals to detect high-risk neonates and give necessary therapies. The results are

Table 4
Bivariable and multivariable analysis of factors associated with neonatal jaundice in public hospitals of southern Ethiopia, 2021 (n = 417).

Variables	COR[a] [95 % CI[b]]	P-value	AOR[c] [95 % CI]	P-value
Sex				
Male	2.13 (1.32, 3.44)	0.002	1.81 (1.06, 3.12)*	0.031
Female	1		1	
Birth injuries				
Yes	4.02 (2.03, 7.96)	0.001	3.01 (1.27, 7.12)*	0.012
No	1		1	
First-minute Apgar score				
<7	2.14 (1.22, 3.75)	0.008	1.69 (0.88, 3.25)	0.115
≥7	1		1	
Labor and delivery complications				
Yes	1.52 (0.96, 2.40)	0.073	1.16 (0.67, 2.01)	0.595
No	1		1	
Perinatal asphyxia				
Yes	1.96 (1.22, 3.14)	0.005	2.10 (1.18, 3.76)*	0.012
No	1		1	
Hyaline membrane disease				
Yes	2.00 (1.18, 3.41)	0.010	2.16 (1.16, 4.00)*	0.015
No	1		1	
Sepsis				
Yes	2.65 (1.50, 4.68)	0.001	3.30 (1.67, 6.54)*	0.001
No	1		1	
Breastfeeding difficulties				
Yes	1.90 (1.21, 3.00)	0.005	1.35 (0.78, 2.39)	0.280
No	1		1	
Hypothermia				
Yes	1.44 (0.92, 2.26)	0.110	1.36 (0.78, 2.39)	0.278
No	1		1	
Low birthweight and prematurity				
Normal[d]	1		1	
LBW alone	0.60 (0.13, 2.75)	0.511	0.59 (0.11, 3.14)	0.539
Preterm alone	1.56 (0.75, 3.26)	0.236	1.41 (0.60, 3.35)	0.430
LBW and preterm	1.98 (1.20, 3.26)	0.008	1.88 (1.06, 3.35)*	0.031
Maternal alcohol abuse during pregnancy				
Yes	1.85 (0.90, 3.81)	0.093	2.46 (1.02, 5.94)*	0.046
No	1		1	
Maternal blood group				
B	1		1	1
A	1.29 (0.60, 2.75)	0.512	0.76 (0.32, 1.82)	0.537
AB	1.21 (0.43, 3.44)	0.714	0.73 (0.23, 2.33)	0.593
O	1.70 (0.84, 3.47)	0.142	1.48 (0.66, 3.31)	0.337
Not recorded	0.79 (0.37, 1.68)	0.545	0.70 (0.30, 1.66)	0.422
Chest in-drawing				
Yes	2.33 (1.34, 4.00)	0.002	1.60 (0.81, 3.18)	0.176
No	1		1	
Meconium aspiration syndrome				
yes	1.77 (0.95, 3.30)	0.071	1.30 (0.62, 2.70)	0.491
No	1		1	

[a] crude odds ratio.
[b] confidence interval.
[c] adjusted odds ratio.
[d] newborns with a birth weight of ≥2500 g and gestational age of ≥37 weeks. *Significant at P-value <0.05. Hosmer-Lemeshow goodness-of-fit test: 0.136.

also used as input to develop protocols for optimal neonatal jaundice prevention and management. Scholars and other stakeholders working on neonatal care will use the findings of this study to initiate interventions or generate more quality evidence with better quantitative and qualitative study designs.

The study has several strengths, including using different data collection techniques such as interviewer-administered questionnaires, review of medical records, and direct observation. In addition, the data was collected electronically using the ODK tools, which helps to avoid incomplete data. Despite its strength, Kramer's scale was used to assess the severity of neonatal jaundice, which is less accurate than the TSB/TcB and understates the burden of neonatal jaundice. Neonatal jaundice was measured only among neonates hospitalized to the NICU, which does not reflect the true burden of the condition. To ascertain the precise degree of neonatal jaundice, additional research measuring serum bilirubin levels and all babies regardless of NICU admission is required. Furthermore, variables such as blood group and Rh factor were collected from medical records, which were incomplete for many participants, making it impossible to determine the status of ABO/Rh incompatibilities accurately. More research is required after including culturally related risk factors and appropriately assessing variables that need laboratory investigation using a prospective study design.

5. Conclusions

Neonatal jaundice was common in the study hospitals, affecting one-fourth of the neonates. Being male, experiencing birth injuries, birth asphyxia, HMD, sepsis, maternal alcohol abuse during pregnancy, and the combined effect of LBW and prematurity were significantly associated with neonatal jaundice. Early screening and treatment of neonatal problems, counseling pregnant women to avoid consuming any level of alcohol, strict monitoring of labor and delivery, improving ANC utilization, and pre-discharge universal bilirubin screening of newborns are imperative to decrease the burden and complications of neonatal jaundice.

Ethical statement

This study was reviewed and approved by the Institutional Review Board (IRB) of Arba Minch University, College of Medicine and Health Sciences, with the approval number IRB/136/12. All newborn's parent/legal guardians provided informed consent to participate in the study.

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Data availability

Data will be made available on request.

CRediT authorship contribution statement

Agegnehu Bante: Writing - review & editing, Writing - original draft, Visualization, Validation, Supervision, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Muluken Ahmed:** Writing - review & editing, Visualization, Validation, Supervision, Methodology, Data curation. **Nega Degefa:** Writing - review & editing, Visualization, Validation, Supervision, Project administration, Methodology, Data curation. **Shitaye Shibiru:** Writing - review & editing, Visualization, Validation, Supervision, Methodology, Data curation. **Manaye Yihune:** Writing - review & editing, Visualization, Validation, Supervision, Project administration, Methodology, Investigation, Data curation.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

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