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Umbilical cord length and its associated factors and birth outcomes among singleton deliveries at Dilla University Referral Hospital, Southern Ethiopia: a hospital-based cross-sectional study

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Research article

Umbilical cord length and its associated factors and birth outcomes among singleton deliveries at Dilla University Referral Hospital, Southern Ethiopia: a hospital-based cross-sectional study

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Abstract

Background: Umbilical cord length is an important component of fetoplacental development and may be associated with adverse perinatal outcomes. However, evidence on umbilical cord length and its determinants in Ethiopia remains limited. This study aimed to determine the mean umbilical cord length, identify associated factors, and assess its relationship with selected birth outcomes among singleton deliveries at Dilla University Referral Hospital, Southern Ethiopia.

Methods: A hospital-based cross-sectional study was conducted among 257 singleton deliveries at Dilla University Referral Hospital from March to May 2025. Data on maternal, obstetric, fetal, placental, and neonatal characteristics were collected using a structured data collection tool. Umbilical cord length was measured after delivery. Simple and multiple linear regression analyses were used to identify factors independently associated with umbilical cord length. Bivariable and multivariable logistic regression analyses were performed to assess associations between umbilical cord length and selected birth outcomes. Associations were reported using regression coefficients or odds ratios with 95% confidence intervals.

Results: The mean umbilical cord length was 56.21 ± 5.02 cm, with a range of 43.38–69.63 cm. In the multiple linear regression model, placental weight (β = 0.012, 95% CI: 0.002–0.021), birth weight (β = 2.173, 95% CI: 0.960–3.386), and gestational age (β = −2.560, 95% CI: −4.989 to −0.130) were independently associated with umbilical cord length. Umbilical cord length was independently associated with fifth-minute Apgar score <7 (AOR = 1.249, 95% CI: 1.022–1.526), retained placenta (AOR = 0.878, 95% CI: 0.794–0.971), and stillbirth (AOR = 0.776, 95% CI: 0.669–0.899).

Conclusion: Umbilical cord length was associated with gestational age, birth weight, and placental weight and showed independent associations with selected perinatal outcomes. These findings suggest that umbilical cord length may provide complementary information about fetoplacental development and perinatal outcomes. However, the observed associations do not establish causality. Larger prospective multicenter studies are needed to establish gestational-age-specific reference ranges and clarify the clinical significance of abnormal umbilical cord length in Ethiopia.

Keywords: Umbilical cord length; birth outcomes; Apgar score; stillbirth; placental weight; birth weight; gestational age; Ethiopia.

1. Introduction

The umbilical cord is an essential component of the fetoplacental unit and provides the vascular connection between the fetus and placenta throughout pregnancy. It facilitates the transport of oxygen and nutrients to the fetus and the removal of metabolic waste products. Structurally, the cord normally contains two umbilical arteries and one umbilical vein embedded within Wharton's jelly, which provides mechanical protection to the umbilical vessels(1). At term, umbilical cord length commonly ranges from approximately 50 to 60 cm, although considerable variation exists among pregnancies. Cord length is influenced by gestational age, fetal growth, placental characteristics, and maternal and fetal factors(2,3).

Umbilical cord length is an important morphological characteristic of the fetoplacental unit because both unusually short and unusually long cords have been associated with adverse obstetric and perinatal outcomes(4). Short cords have been associated with fetal distress and selected complications of labor and placental separation, whereas excessively long cords may increase the likelihood of nuchal cord, cord entanglement, true knots, and other mechanical abnormalities that can compromise umbilical blood flow. Consequently, abnormal cord length has been associated with adverse outcomes including low Apgar scores, fetal distress, and stillbirth, although the magnitude and direction of these associations vary across populations(2,3,5). Importantly, the clinical significance of cord length may depend not only on its absolute length but also on other characteristics of the cord, such as coiling, insertion abnormalities, knots, and entanglement.

Umbilical cord growth also appears to occur in parallel with fetal and placental development. Large population-based studies have demonstrated positive associations between cord length, birth weight, placental weight, and gestational age, suggesting that cord length reflects aspects of overall fetoplacental growth (2,3). However, associations with maternal characteristics, including parity, nutritional status, body mass index, hypertensive disorders, smoking, and alcohol exposure, have been inconsistent across studies (5–7). Similarly, the relationships between cord length and fetal sex, fetal growth, and other maternal or obstetric characteristics have varied between populations. These inconsistencies indicate that umbilical cord development is multifactorial and may be influenced by genetic, environmental, nutritional, and population-specific factors.

Despite the clinical and developmental importance of umbilical cord length, evidence from sub-Saharan Africa remains limited, and locally relevant data from Ethiopia are particularly scarce. A study conducted in Hadiya Zone, Southern Ethiopia, reported an association between abnormal umbilical cord length and fetal distress; however, cord length was primarily evaluated using categorical classifications rather than as a continuous measurement (8). Consequently, limited evidence is available from Southern Ethiopia regarding the distribution of umbilical cord length as a continuous variable and its independent relationships with fetal, placental, maternal, and obstetric characteristics and selected birth outcomes. Differences in maternal nutritional status, fetal growth patterns, obstetric characteristics, socioeconomic conditions, and healthcare settings may contribute to variations in cord length and its clinical associations across populations(2). Generating evidence from local populations is therefore important for improving understanding of umbilical cord morphology and its relationship with perinatal outcomes.

Determining the factors associated with umbilical cord length may provide useful complementary information for placental and perinatal assessment and may contribute to improved documentation of clinically relevant cord abnormalities(9). Nevertheless, cord length should not be interpreted as an independent diagnostic marker of adverse outcomes without population-specific evidence. Establishing its distribution and determining whether associations with selected birth outcomes persist after accounting for relevant maternal and obstetric characteristics are important steps toward understanding its potential clinical relevance(10).

Therefore, this study aimed to determine the mean umbilical cord length, identify factors associated with umbilical cord length, and assess its association with selected birth outcomes among singleton deliveries at Dilla University Referral Hospital, Dilla, Southern Ethiopia.

2. MATERIALS AND METHODS

2.1. Study Area and Period

The study was conducted at Dilla University Referral Hospital (DURH), Dilla, Southern Ethiopia, from March 1 to May 31, 2025. Dilla is located approximately 360 km south of Addis Ababa, the capital city of Ethiopia. Dilla University Referral Hospital is a tertiary teaching and referral hospital affiliated with Dilla University College of Medicine and Health Sciences. The hospital serves as a major referral center for Dilla City and the surrounding districts of Southern Ethiopia, providing comprehensive preventive, promotive, curative, and rehabilitative healthcare services(11).

The hospital delivers comprehensive maternal and newborn healthcare services, including antenatal care, intrapartum care, postnatal care, emergency obstetric and newborn care, neonatal services, family planning, and gynecological care. The Department of Obstetrics and Gynecology comprises antenatal care clinics, labor and delivery wards, maternity wards, gynecology wards, gynecology outpatient clinics, operating theaters for obstetric and gynecological procedures, and family planning services. The hospital manages a high volume of deliveries each year, making it an appropriate setting for investigating umbilical cord length and its association with birth outcomes.

2.2. Study Design and Setting

A hospital-based cross-sectional study was conducted among women who delivered singleton newborns at Dilla University Referral Hospital (DURH), Dilla, Southern Ethiopia, from March 1 to May 31, 2025. Dilla is located approximately 360 km south of Addis Ababa, the capital of Ethiopia. DURH is a tertiary teaching and referral hospital affiliated with Dilla University College of Medicine and Health Sciences and provides maternal and newborn healthcare services to the population of Dilla and surrounding areas.

The study was conducted among eligible women who delivered singleton newborns during the study period. Maternal, obstetric, fetal, placental, and neonatal characteristics were assessed, and umbilical cord length was measured following delivery. The study was designed to determine the distribution of umbilical cord length, identify factors associated with its variation, and assess its association with selected birth outcomes.

2.3. Study Population

2.3.1. Source Population

The source population comprised all women with singleton pregnancies who delivered at Dilla University Referral Hospital during the study period.

2.3.2. Study Population

The study population consisted of all eligible mother–newborn pairs who met the predefined eligibility criteria and were enrolled during the study period.

2.4. Eligibility Criteria

2.4.1. Inclusion Criteria

Mother–newborn pairs were eligible for inclusion if they met all of the following criteria:

- Singleton delivery.
- Live birth or stillbirth.
- Provision of written informed consent by the mother before participation.

2.4.2. Exclusion Criteria

Mother–newborn pairs were excluded if any of the following conditions were present:

- Multiple pregnancy.
- Congenital fetal anomalies that could affect umbilical cord morphology.
- Umbilical cords that were severely damaged, ruptured, or could not be measured accurately after delivery.
- Mothers who were critically ill or otherwise unable to participate in the interview or data collection procedures.

2.5. Sample Size Determination

Sample size was determined by using single population proportion formula based on the following assumptions: since there is no prior study regarding umbilical cord length and its association with birth outcomes in Ethiopia, to determine required sample size, the proportion (p) was taken as 0.5 at 95% confidence level and at margin of error (5%)

$$n_0 = \frac{(Z_{\alpha/2})^2 p(1-p)}{d^2}$$

Where: n_0 is the initial sample size, $Z_{\alpha/2}$=1.96 is the standard normal value corresponding to a 95% confidence level, p=0.50 is the assumed population proportion, and d=0.05 is the margin of error. Accordingly,

$$n_0 = \frac{(1.96)^2(0.50)(1-0.50)}{(0.05)^2} = 384.$$

The estimated source population of eligible singleton deliveries during the corresponding three-month period was 597. Since the source population was less than 10,000, a finite population correction was applied:

$$n_f = \frac{n_0}{1 + \frac{n_0 - 1}{N}}$$

Where nf= final sample size, n_o= initial sample size, The total number of deliveries recorded during the same calendar month in the previous year was 597, based on the delivery registration book of the labor ward at Dilla University Referral Hospital. This figure was used as the estimated source population ((N)) for the finite population correction. N=597. Thus,

Substituting the values with in the formula gives $nf = \frac{no}{1+\frac{n}{N}} = \frac{384}{1+\frac{384}{597}} = 233.7 \approx 234$

Ten percent was added to account for potential incomplete data, resulting in a final target sample size of approximately 257 participants.

2.5.1. Sampling Technique

A consecutive sampling technique was employed. All eligible mother–newborn pairs presenting to the labor and delivery unit at Dilla University Referral Hospital during the study period were consecutively enrolled until the required sample size of 257 participants was attained. Eligibility was assessed according to the predefined inclusion and exclusion criteria, and each eligible participant was enrolled only once.

2.6. Variables of the study

2.6.1. Dependent Variables

The dependent variables of the study were:

- Umbilical cord length (continuous variable, measured in centimeters).

- Birth outcomes, including first- and fifth-minute Apgar scores, neonatal intensive care unit (NICU) admission, stillbirth, placental abruption, retained placenta, prolonged labor, prolonged second stage of labor, cord complications, and mode of delivery.

2.6.2. Independent Variables

The independent variables included:

- Maternal socio-demographic characteristics: maternal age, marital status, educational level, and monthly household income.
- Maternal obstetric and medical characteristics: gravidity, parity, gestational hypertension, gestational diabetes mellitus, and gestational age.
- Maternal behavioral characteristics: alcohol consumption during pregnancy and cigarette smoking (active or passive exposure).
- Fetal and placental characteristics: fetal sex, birth weight, fetal presentation, and placental weight.

2.7. Operational definitions and terms of definitions

Umbilical cord length: The total length of the umbilical cord, measured in centimeters from the fetal umbilical stump to the placental insertion site by summing the fetal and placental segments after routine clamping and cutting.

Birth outcomes: Maternal and neonatal outcomes assessed immediately after delivery, including first- and fifth-minute Apgar scores, NICU admission, stillbirth, placental abruption, retained placenta, prolonged labor, prolonged second stage of labor, cord complications, and mode of delivery.

Alcohol consumption during pregnancy: Maternal self-reported consumption of any alcoholic beverage at least once during the current pregnancy(12).

Maternal cigarette smoking: Maternal exposure to cigarette smoke during pregnancy, categorized as active smoking (the mother smoked cigarettes during pregnancy), passive smoking (the mother was regularly exposed to cigarette smoke from household members or others), or non-smoking (no active or passive exposure).

2.8. Data Collection Tools and Procedures

A pre-tested, structured interviewer-administered questionnaire was used to collect quantitative data, supplemented by medical record review and direct physical measurements. The questionnaire was adapted from standard data collection instruments and previously published literature and modified to address the objectives of the study(2,4,6,13–17).

The questionnaire was pre-tested on 5% of the calculated sample size among mothers delivering at a health facility outside the study area with similar sociodemographic and obstetric characteristics. Based on the pre-test findings, necessary modifications were made to improve the clarity, consistency, logical sequence, and completeness of the instrument. The questionnaire was prepared in English, translated into Amharic and Gedeuffa, and independently back-translated into English by bilingual language experts to ensure semantic equivalence.

Data were collected in the labor and delivery unit of Dilla University Referral Hospital by two trained BSc midwives under the supervision of an obstetrics and gynecology resident. Before data collection, the data collectors and supervisor received standardized training on the study objectives, participant recruitment, interviewing techniques, questionnaire completion, measurement procedures, confidentiality, and ethical considerations.

Following delivery and maternal stabilization, sociodemographic and behavioral information was collected through face-to-face interviews. Clinical and obstetric information, including gravidity, parity, fetal presentation, gestational diabetes mellitus, hypertensive disorders of pregnancy, and gestational age, was obtained from maternal medical records using a standardized data-abstraction checklist.

Immediately after delivery, the umbilical cord was examined for visible abnormalities, including nuchal cord, body loops, true knots, and false knots. Following routine clamping and cutting, the cord was measured using a calibrated, non-stretchable measuring tape. The fetal and placental cord segments were measured separately and summed to obtain the total umbilical cord length, which was recorded to the nearest 0.1 cm.

Neonatal sex, birth weight, first- and fifth-minute Apgar scores, NICU admission, and stillbirth status were recorded immediately after birth. Birth weight was measured using a calibrated digital neonatal weighing scale. Placental weight was measured immediately after delivery using a

calibrated digital weighing scale after trimming the fetal membranes and removing the umbilical cord according to standard obstetric procedures. Maternal delivery outcomes, including prolonged labor, prolonged second stage of labor, placental abruption, retained placenta, and mode of delivery, were obtained from the medical record.

2.9. Data Quality Control

Several measures were implemented to ensure the quality and reliability of the study data. The data collection instrument was pre-tested before the main data collection, and necessary revisions were made based on the pre-test findings. Data collectors and the supervisor received standardized training on the study objectives, data collection procedures, ethical considerations, questionnaire administration, and measurement techniques.

During the data collection period, the supervisor and principal investigator conducted regular supervision and field observations. Completed questionnaires were reviewed daily for completeness, consistency, and accuracy, and any identified omissions or inconsistencies were verified and corrected promptly when possible.

Standard operating procedures were followed for measuring umbilical cord length, placental weight, and neonatal birth weight. Measuring tapes and digital weighing scales were calibrated before data collection and checked regularly throughout the study to minimize measurement error. Data were coded using standardized coding procedures, and entered data were checked for completeness and consistency before statistical analysis.

2.10. Data Processing and Statistical Analysis

Completed questionnaires were checked for completeness, coded, cleaned, and entered into EpiData version 4.1 before being exported to IBM SPSS Statistics version 26.0 for statistical analysis. Descriptive statistics were used to summarize the study participants and study variables. Continuous variables were summarized using means and standard deviations (SD), while categorical variables were presented using frequencies and percentages.

Normality of continuous variables was assessed using the Shapiro–Wilk test together with visual inspection of histograms and normal Q–Q plots. Bivariable linear regression analysis was performed to assess the association between the independent variables and umbilical cord length. Variables with a p-value <0.25 in the bivariable analysis were considered candidates for the

multivariable linear regression model. A multivariable linear regression model was then fitted to identify independent predictors of umbilical cord length while controlling for potential confounding.

Before fitting the final linear regression model, the assumptions of linearity, normality of residuals, homoscedasticity, independence of errors, and absence of problematic multicollinearity were assessed. Multicollinearity was evaluated using the variance inflation factor (VIF), with VIF values <10 considered acceptable. Independence of residuals was assessed using the Durbin–Watson statistic, while influential observations were evaluated using standardized residuals, leverage values, and Cook's distance. Model adequacy was assessed using the coefficient of determination (R^2), adjusted R^2, and residual diagnostic plots.

Bivariable logistic regression analysis was used to examine the association between umbilical cord length and selected adverse birth outcomes. Variables considered clinically relevant or having a p-value <0.25 in the bivariable analysis were entered into the corresponding multivariable logistic regression models. Model fit was assessed using the Hosmer–Lemeshow goodness-of-fit test.

For the linear regression analysis, the strength of association was presented using unstandardized regression coefficients (β) with corresponding 95% confidence intervals (CI). For logistic regression analyses, associations were presented using adjusted odds ratios (AORs) with 95% CIs. A two-sided p-value <0.05 was considered statistically significant.

2.11. Ethical Considerations

Ethical approval was obtained from the Institutional Review Board (IRB) of Dilla University, College of Medicine and Health Sciences. Following ethical approval, an official letter of cooperation was submitted to Dilla University Referral Hospital, and permission was obtained from the hospital administration before the commencement of data collection.

Written informed consent was obtained from all study participants after providing a detailed explanation of the study objectives, procedures, potential benefits, and any foreseeable risks. Participation was entirely voluntary, and participants were informed of their right to decline participation or withdraw from the study at any stage without affecting the healthcare services they received.

Confidentiality and privacy were maintained throughout the study by assigning unique identification codes instead of personal identifiers. All collected information was kept confidential, stored securely, and used solely for the purposes of this research in accordance with the principles of the Declaration of Helsinki.

3. RESULTS

3.1. Sociodemographic Characteristics of the Participants

A total of 257 mother–newborn pairs were included in the analysis. Maternal age ranged from 18 to 37 years, with a mean (SD) of 25.95 ± 4.68 years. Most mothers were younger than 35 years (244, 94.9%) and married (249, 96.9%). Regarding educational attainment, 101 (39.3%) had completed primary education, while 52 (20.2%) had attained college-level education or above. Nearly half of the mothers were housewives (125, 48.6%). The mean (SD) monthly household income was 3,100 ± 1,739.5 Ethiopian Birr (ETB). Detailed sociodemographic characteristics are presented in *Table 1*.

Table 1:Sociodemographic Characteristics of Mothers Who Delivered at Dilla University Referral Hospital, Dilla, Southern Ethiopia, March–May 2025 (N = 257)

Characteristic	***Category***	***N***	***%***
Maternal age (years)	<35	244	94.9
	≥35	13	5.1
	Mean ± SD	**25.95 ± 4.68**	
Marital status	Married	249	96.9
	Single	3	1.2
	Divorced	4	1.6
	Widowed	1	0.4
Educational status	No formal education	40	15.6
	Primary education	101	39.3
	Secondary education	64	24.9
	College and above	52	20.2
Occupation	Housewife	125	48.6
	Government employee	65	25.3
	Merchant	28	10.9
	Farmer	34	13.2
	Unemployed	5	1.9
Monthly household income (ETB)	≤1000	**31**	12.1
	1001-2000	**51**	19.8
	2001-3000	**75**	29.2
	3001-4000	**48**	18.7
	≥4000	**52**	20.2

Abbreviations: SD, standard deviation; ETB, Ethiopian Birr.

3.2. Neonatal Characteristics of the Study Participants

The clinical and obstetric characteristics of the participants and their newborns are presented in *Table 2*. Most deliveries occurred at term, with 237 (92.2%) newborns delivered at term and 20 (7.8%) delivered preterm. The mean birth weight was 3.04 ± 0.58 kg, while the mean placental weight was 534.78 ± 65.30 g. The distribution of fetal sex and presentation is presented in *Table2*.

Table 2: Neonatal and Placental Characteristics of Singleton Newborns Delivered at Dilla University Referral Hospital, Dilla, Southern Ethiopia, March–May 2025 (N = 257)

Variable	***Category***	***n (%)***	***Mean ± SD***
Neonatal sex	Male	129(50.200	
	Female	128(49.8)	
Gestational age	Preterm (<37 weeks)	20(7.8)	
	Term (37–42 weeks)	237(92.2)	
Birth weight (kg)	Mean ± SD		3.04 ± 0.58
	Range	1.00–4.20	
Placental weight (g)	Mean ± SD		534.78 ± 65.30

Abbreviations: SD, standard deviation.

3.3. Maternal Obstetric, Behavioral, and Medical Characteristics

Of the 257 mothers included in the study, 102 (39.7%) were primigravida, while 155 (60.3%) were multigravida. Similarly, 119 (46.3%) mothers were primiparous, whereas 138 (53.7%) were multiparous. The majority of pregnancies (237, 92.2%) reached term (37–42 completed weeks of gestation), while 20 (7.8%) resulted in preterm delivery.

Regarding fetal presentation, 248 (96.5%) newborns presented in the cephalic position, whereas 9 (3.5%) had non-cephalic presentations. Maternal medical conditions were relatively uncommon; hypertensive disorders of pregnancy and gestational diabetes mellitus were identified in only a small proportion of participants.

Most mothers reported no alcohol consumption or cigarette smoking during the current pregnancy. The detailed distribution of maternal obstetric characteristics, behavioral factors, and medical conditions is presented in *Table 3*.

Table 3: Maternal Obstetric, Behavioral, and Medical Characteristics of Mothers Who Delivered at Dilla University Referral Hospital, Dilla, Southern Ethiopia, March–May 2025 (N = 257)

Characteristic	***Category***	***n (%)***
Gravidity	Primigravida	102 (39.7)
	Multigravida	155 (60.3)
Parity	Primiparous	119 (46.3)
	Multiparous	138 (53.7)
Fetal presentation	Cephalic	248 (96.5)
	Non-cephalic	9 (3.5)
Hypertensive disorders of pregnancy	Yes	*23(8.9)*
	No	234 (91.1)
Alcohol consumption during pregnancy	Yes	10 (3.9)

Cigarette smoking	No	247 (96.1)
	Passive smoker	7 (2.7)
	Non-smoker	250 (97.3)

Abbreviations: GDM, gestational diabetes mellitus.

3.4. Descriptive statistics of Birth outcome

Among the 257 newborns, 40 (15.6%) had a first-minute Apgar score <7, while 20 (7.8%) had a fifth-minute Apgar score <7. Fifteen newborns (5.8%) were admitted to the neonatal intensive care unit. There were 245 (95.3%) live births and 12 (4.7%) stillbirths. Placental abruption occurred in 9 (3.5%) mothers and retained placenta in 5 (1.9%). Prolonged labor and prolonged second stage of labor occurred in 26 (10.1%) and 21 (8.2%) mothers, respectively. Most participants, 204 (79.4%), had spontaneous vaginal delivery, while 53 (20.6%) had operative delivery *(Table 4)*

Table 4: Descriptive statistics of maternal and neonatal birth outcomes among singleton deliveries at Dilla University Referral Hospital, Dilla, Southern Ethiopia, March–May 2025 (n = 257).

Variable	***Category***	***n (%)***
First-minute Apgar score	<7	40 (15.6)
	≥7	217 (84.4)
Fifth-minute Apgar score	<7	20 (7.8)
	≥7	237 (92.2)
Neonatal intensive care unit (NICU) admission	Yes	15 (5.8)
	No	242 (94.2)
Birth status	Live birth	245 (95.3)
	Stillbirth	12 (4.7)
Placental abruption	Yes	9 (3.5)
	No	248 (96.5)
Retained placenta	Yes	5 (1.9)
	No	252 (98.1)
Prolonged labor	Yes	26 (10.1)
	No	231 (89.9)
Prolonged second stage of labor	Yes	21 (8.2)
	No	236 (91.8)
Mode of delivery	Spontaneous vaginal delivery	204 (79.4)
	Operative delivery	53 (20.6)

Abbreviations: NICU, Neonatal Intensive Care Unit.

3.5. Umbilical Cord Length Distribution

The mean umbilical cord length among the 257 singleton deliveries was 56.21 ± 5.02 cm, with a range of 43.38–69.63 cm. The distribution of umbilical cord length was approximately normal, with most observations clustered around the mean *(Fig. 1).* The mean cord length was higher among term newborns (56.62 cm) than among preterm newborns (51.20 cm). Higher mean cord lengths were also observed among female newborns, newborns with a birth weight ≥2500 g, and those with cephalic presentation. Maternal characteristics showed some variation in mean cord length; however, these unadjusted differences were further evaluated using regression analysis.

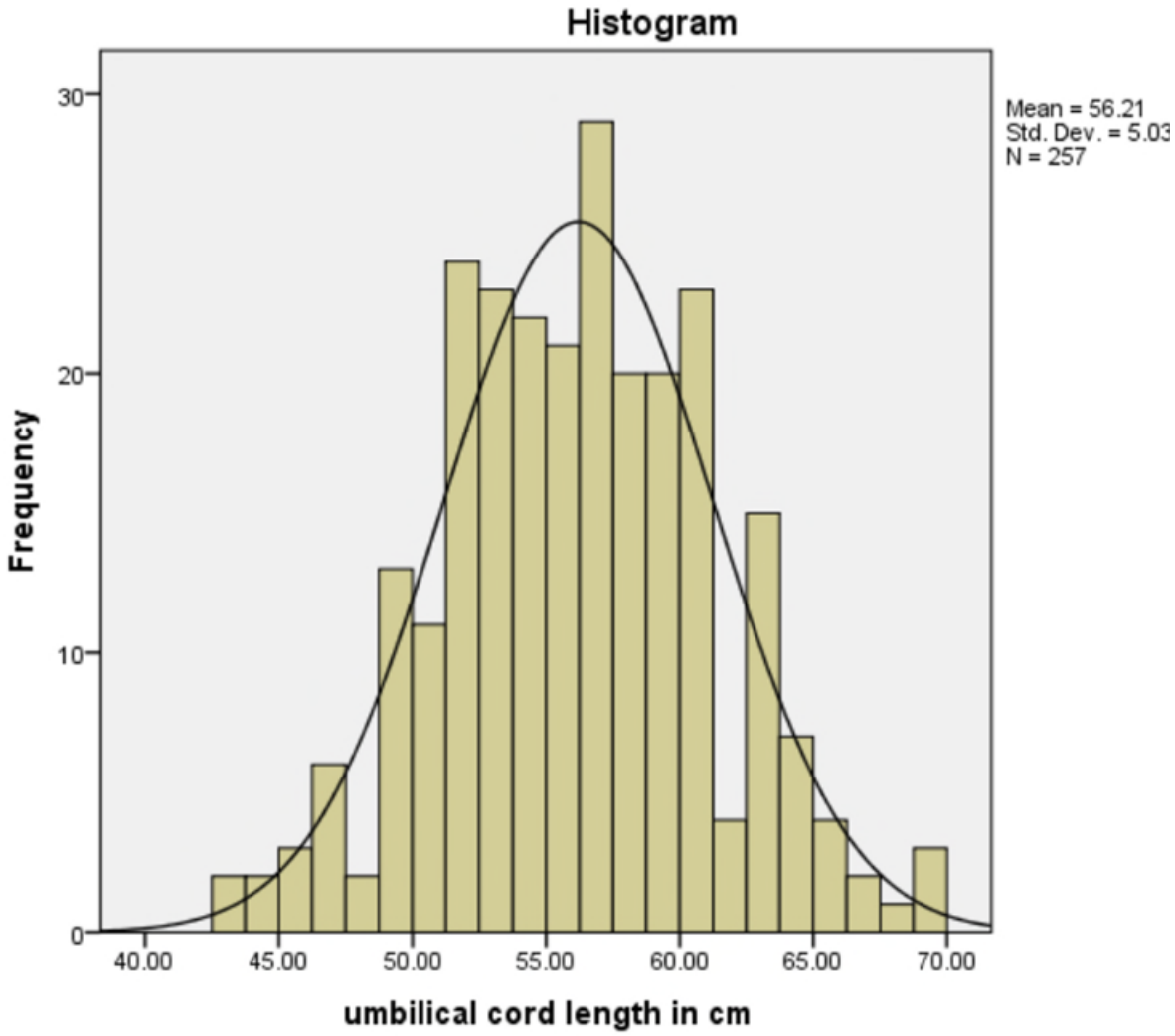


Figure 1: Histogram showing the distribution of umbilical cord length among singleton newborns delivered at Dilla University Referral Hospital, Dilla, Southern Ethiopia, March–May 2025 (n = 257)

3.6. Factors Associated with Umbilical Cord Length

Bivariable linear regression analysis was initially performed to identify variables potentially associated with umbilical cord length. Variables with a p-value <0.25 in the bivariable analysis were considered candidates for inclusion in the multivariable linear regression model. Accordingly, nine variables met the predefined criterion: marital status, alcohol consumption during pregnancy, maternal smoking history, parity, gravidity, placental weight, gestational age, fetal presentation, and birth weight. Before fitting the multivariable model, multicollinearity among the independent variables was assessed using the variance inflation factor (VIF). The VIF values ranged from 1.03 to 1.80, indicating no evidence of problematic multicollinearity.

In the multivariable linear regression analysis, placental weight, birth weight, and gestational age remained independently associated with umbilical cord length (Table 5). Placental weight was positively associated with umbilical cord length (β = 0.012, 95% CI: 0.002–0.021), indicating that each 100-g increase in placental weight was associated with an average increase of approximately 1.2 cm in umbilical cord length. Birth weight was also positively associated with umbilical cord length (β = 2.173, 95% CI: 0.960–3.386), indicating that each 1-kg increase in birth weight was associated with an average increase of approximately 2.17 cm in cord length. In contrast, preterm birth was associated with a shorter umbilical cord compared with term birth (β = −2.560, 95% CI: −4.989 to −0.132), corresponding to an adjusted mean difference of approximately 2.56 cm

The final multivariable linear regression model explained 21.6% of the variability in umbilical cord length ($R^2 = 0.216$), with an adjusted R^2 of 0.178. Detailed regression results are presented in *Tables 5 and 6.*

Table 5: Bivariable and multivariable linear regression analyses of factors associated with umbilical cord length among singleton deliveries at Dilla University Referral Hospital, Dilla, Southern Ethiopia, March–May 2025 (N = 257).

Variable	*Category*	*Mean UCL ± SD (cm)*	*Bivariable β (95% CI)*	*Multivariable β (95% CI)*
Marital status	Married	56.28 ± 5.02	−1.372 (−3.260, 0.525)	5.680 (−3.390, 14.760)
	Single	57.00 ± 8.26	0.810 (−4.961, 6.582)	6.792 (−3.750, 17.330)
	Divorced	54.03 ± 1.64	−2.210 (−7.211, 2.792)	4.940 (−5.140, 15.022)
	Widowed	48.75	1	1
Maternal smoking history	Passive smoker	58.80 ± 3.99	−1.336 (−3.230, 0.562)	1.970 (−1.730, 5.680)
	Never smoker	56.10 ± 5.05	1	1
Alcohol consumption during pregnancy	Yes	58.84 ± 4.56	−2.748 (−5.930, 0.440)	1.193 (−1.920, 4.315)
	No	56.09 ± 5.03	1	1
Parity	Primiparous	55.42 ± 5.08	1	1
	Multiparous	56.65 ± 4.96	1.231 (−0.048, 2.509)	0.352 (−1.128, 1.832)
Fetal presentation	Breech	54.40 ± 5.35	−1.825 (−3.910, 0.260)	2.581 (−4.184, 9.346)
	Cephalic	56.35 ± 5.01	1	1
Gestational age	Preterm	51.20 ± 4.97	−5.380 (−7.605, −3.170)	−2.560 (−4.989, −0.130)*
	Term	56.62 ± 4.82	1	1
Placental weight (g)	—	—	0.023 (0.014, 0.032)	0.012 (0.002, 0.021)*
Birth weight (kg)	—	—	3.452 (2.478, 4.425)	2.173 (0.960, 3.386)*
Gravidity	—	—	0.271 (−0.130, 0.671)	0.109 (−0.350, 0.563)

Abbreviations: UCL, umbilical cord length; CI, confidence interval. **Notes**: * *p-value*; 1 = reference category; —Continuous variables

Table 6: Summary of the final multivariable linear regression model for factors associated with umbilical cord length among singleton deliveries at Dilla University Referral Hospital, Dilla, Southern Ethiopia, March–May 2025 (n = 257).

Model statistic	*Value*
Multiple correlation coefficient (R)	0.465
Coefficient of determination (R^2)	0.216
Adjusted R^2	0.178
Standard error of the estimate	4.567
Durbin–Watson statistic	1.782

Abbreviations: R, multiple correlation coefficient; R^2, coefficient of determination.

Note: The final multivariable linear regression model explained 21.6% of the variability in umbilical cord length ($R^2 = 0.216$), with an adjusted R^2 of 17.8%.

3.7. Association between Umbilical Cord Length and Birth Outcomes

In bivariable logistic regression analysis, umbilical cord length was significantly associated with a fifth-minute Apgar score <7 (COR = 1.259, 95% CI: 1.021–1.554), retained placenta (COR = 0.887, 95% CI: 0.805–0.977), and stillbirth (COR = 0.783, 95% CI: 0.681–0.900). No statistically significant associations were observed between umbilical cord length and first-minute Apgar score, NICU admission, placental abruption, prolonged labor, prolonged second stage of labor, mode of delivery, or recorded umbilical cord complications *Table 7.*

After adjustment for maternal age, parity, and hypertensive disorders of pregnancy, umbilical cord length remained independently associated with fifth-minute Apgar score <7 (AOR = 1.249, 95% CI: 1.022–1.526), retained placenta (AOR = 0.878, 95% CI: 0.794–0.971), and stillbirth (AOR = 0.776, 95% CI: 0.669–0.899). Thus, each 1-cm increase in umbilical cord length was associated with a 24.9% increase in the odds of a fifth-minute Apgar score <7, a 12.2% reduction in the odds of retained placenta, and a 22.4% reduction in the odds of stillbirth *Table 8.*

Table 7: Bivariable logistic regression analysis of the association between umbilical cord length and selected birth outcomes among singleton deliveries at Dilla University Referral Hospital, Dilla, Southern Ethiopia, March–May 2025 (N = 257).

Outcome	*Category*	*Mean UCL ± SD (cm)*	*COR (95% CI)*
First-minute Apgar score	<7	54.80 ± 5.91	0.935 (0.873, 1.000)
	≥7	56.46 ± 4.82	1
Fifth-minute Apgar score	<7	61.79 ± 4.11	1.259 (1.021, 1.554)*
	≥7	56.10 ± 5.00	1
NICU admission	Yes	55.64 ± 5.71	0.976 (0.880, 1.084)
	No	56.24 ± 5.00	1
Placental abruption	Yes	54.25 ± 4.67	0.922 (0.805, 1.055)
	No	56.27 ± 5.04	1
Retained placenta	Yes	53.53 ± 6.75	0.887 (0.805, 0.977)*
	No	56.43 ± 4.81	1
Prolonged labor	Yes	56.68 ± 3.96	1.021 (0.942, 1.107)
	No	56.15 ± 5.14	1
Prolonged second stage of labor	Yes	56.86 ± 5.91	1.029 (0.910, 1.124)
	No	56.14 ± 4.95	1
Mode of delivery	Operative delivery	55.64 ± 4.42	0.972 (0.915, 1.033)
	Spontaneous vaginal delivery	56.35 ± 5.18	1
Stillbirth	Yes	51.01 ± 6.19	0.783 (0.681, 0.900)*
	No	56.40 ± 4.88	1

Abbreviations: UCL, umbilical cord length; SD, standard deviation; COR, crude odds ratio; CI, confidence interval; NICU, neonatal intensive care unit.

Note: 1 = reference category. COR represents the crude odds ratio obtained from bivariable logistic regression analysis. *$p < 0.05$.

Table 8: Multivariable logistic regression analysis of the association between umbilical cord length and selected birth outcomes among singleton deliveries at Dilla University Referral Hospital, Dilla, Southern Ethiopia, March–May 2025 (n = 257).

Predictor	***Category***	***Retained placenta AOR (95% CI)***	***Fifth-minute Apgar score <7 AOR (95% CI)***	***Stillbirth AOR (95% CI)***
Maternal age	<35 years	1	1	1
	≥35 years	0.375 (0.024–3.260)	0.275 (0.024–3.150)	0.930 (0.804–1.066)
Parity	Multiparous	1	1	1
	Primiparous	2.543 (0.855–7.560)	0.950 (0.920–1.040)	1.947 (0.504–7.519)
Hypertensive disorders of pregnancy	No	1	1	1
	Yes	0.260 (0.070–1.055)	0.213 (0.018–2.550)	0.113 (0.024–1.526)
Umbilical cord length (cm)	---------	0.878 (0.794–0.971)	1.249 (1.022–1.526)	0.776 (0.669–0.899)

Abbreviations: AOR, adjusted odds ratio; CI, confidence interval.

Note: 1 = reference category. AOR represents the adjusted odds ratio obtained from multivariable logistic regression analysis. Umbilical cord length was entered as a continuous predictor.

4. Discussion

This study assessed umbilical cord length (UCL), its associated factors, and its relationship with selected birth outcomes among 257 singleton deliveries at Dilla University Referral Hospital, Southern Ethiopia. The mean UCL was 56.21 ± 5.02 cm (range, 43.38–69.63 cm). Placental weight, birth weight, and gestational age were independently associated with UCL, while UCL was also independently associated with fifth-minute Apgar score <7, retained placenta, and stillbirth. These findings support the interpretation of UCL as a component of fetoplacental development and suggest that its clinical relevance may depend on both fetal and placental characteristics.

The mean UCL in the present study was comparable with findings from Southern Nigeria, where *Makinde and Osegi (2023)* reported a mean of 55.75 ± 7.10 cm (18), but differences have been reported across populations. In Hadiya Zone, Southern Ethiopia, *Meskele et al. (2021)* classified 32.9% of cords as short, 61.8% as normal, and 5.2% as long.(8). Differences in population characteristics, gestational-age distribution, measurement procedures, and classification methods may explain these variations. Consistent with the present findings, large population-based studies from Finland and Norway have demonstrated substantial variation in UCL according to gestational age, birth weight, placental weight, fetal characteristics, and maternal factors (2,3). These findings support the interpretation of UCL as a multifactorial fetoplacental characteristic rather than a fixed population-specific measurement.

Placental weight was positively associated with UCL, with every 100-g increase in placental weight corresponding to approximately a 1.2-cm increase in UCL. Similarly, a 1-kg increase in birth weight was associated with a 2.17-cm increase in UCL ($\beta = 2.173$; 95% CI: 0.96–3.39). These findings are consistent with the Finnish population-based study of 47,284 singleton pregnancies, which identified placental weight and birth weight as important correlates of UCL (2), and with the Norwegian study involving more than 850,000 singleton births (3). The findings are biologically plausible because fetal growth, placental development, and umbilical vascular development occur as interconnected components of fetoplacental growth. However, these associations should not be interpreted as evidence of direct causation, as shared developmental, maternal, and intrauterine factors may influence all three characteristics.

Birth weight was also independently associated with UCL. Each 1-kg increase in birth weight was associated with an approximately 2.17-cm increase in UCL (β = 2.173, 95% CI: 0.960–3.386). This finding agrees with large population-based evidence demonstrating an association between fetal size and cord length (2,3). The relationship further supports the concept that cord development occurs in parallel with overall fetal and placental growth. Nevertheless, the magnitude of this association should not be interpreted as evidence that increasing fetal weight directly causes cord elongation.

Gestational age was another independent determinant of UCL. Preterm newborns had a mean UCL of 51.20 ± 4.97 cm compared with 56.62 ± 4.82 cm among term newborns, while preterm birth remained associated with a 2.56-cm shorter cord after adjustment (β = −2.560, 95% CI: −4.989 to −0.132). This finding is consistent with previous population-based evidence showing progressive increases in cord length with gestational age (2,3). It also suggests that interpretation of cord length should take gestational age into account rather than relying on a single universal threshold for defining an abnormally short cord.

The association between UCL and fifth-minute Apgar score <7 was also noteworthy. Each 1-cm increase in UCL was associated with a 24.9% increase in the odds of a fifth-minute Apgar score <7 (AOR = 1.249, 95% CI: 1.022–1.526). This finding should be interpreted cautiously because UCL itself is unlikely to directly cause neonatal depression. Longer cords may provide greater opportunity for nuchal loops, entanglement, knots, or torsion, potentially increasing susceptibility to transient or persistent compromise of umbilical blood flow during labor. Findings from Hadiya Zone are relevant in this regard, where both short and long cords were associated with fetal distress (8). The present analysis treated UCL as a continuous linear exposure and therefore cannot establish whether the observed association reflects an effect of excessive cord length or a nonlinear relationship at the extremes. The relatively small number of newborns with a fifth-minute Apgar score <7 also warrants cautious interpretation.

UCL was inversely associated with retained placenta. Each 1-cm increase in UCL was associated with a 12.2% reduction in the odds of retained placenta (AOR = 0.878, 95% CI: 0.794–0.971). Although this association is potentially clinically interesting, only five cases of retained placenta occurred in the study population. Consequently, the estimate may be imprecise. Retained placenta is primarily related to abnormal placental separation and adherence, and the present study did not

assess the specific mechanisms that could link cord length to this complication. Accordingly, this finding should be regarded as an observed association requiring confirmation in larger studies rather than evidence of a causal relationship.

The inverse association between UCL and stillbirth was similarly important. Stillborn newborns had a mean UCL of 51.01 ± 6.19 cm compared with 56.40 ± 4.88 cm among live births. After adjustment, each 1-cm increase in UCL was associated with a 22.4% reduction in the odds of stillbirth (AOR = 0.776, 95% CI: 0.669–0.899). This finding is broadly consistent with evidence from Norway showing increased risks of adverse perinatal outcomes at abnormal cord lengths, particularly at the extremes of the distribution (3). However, stillbirth is multifactorial, and the present study did not establish whether shorter UCL independently contributes to fetal death or acts as a marker of abnormal fetoplacental development. The relatively small number of stillbirths in this study further supports cautious interpretation.

No statistically significant association was observed between UCL and first-minute Apgar score, NICU admission, placental abruption, prolonged labor, prolonged second stage of labor, mode of delivery, or recorded cord-related complications. The absence of significant associations should not necessarily be interpreted as evidence that UCL has no relevance to these outcomes. Several of these outcomes are determined by multiple maternal, fetal, placental, and intrapartum factors, while some were relatively uncommon in the present sample. In addition, adverse effects of cord abnormalities may depend more on specific characteristics such as knots, entanglement, insertion abnormalities, and coiling than on absolute cord length alone.

The findings have potential relevance for maternity care in Ethiopia, where locally generated evidence on umbilical cord characteristics remains limited. Routine documentation of UCL together with other placental and cord characteristics may provide useful information for perinatal assessment and audit, particularly following stillbirth or unexplained neonatal compromise. However, the present findings do not support using UCL alone as a diagnostic or screening measure for adverse birth outcomes. Rather, UCL should be interpreted together with gestational age, fetal growth, placental characteristics, and other cord abnormalities.

Overall, the findings indicate that UCL is closely associated with fetal and placental growth, with placental weight, birth weight, and gestational age emerging as independent determinants. The observed associations with fifth-minute Apgar score, retained placenta, and stillbirth suggest

potential clinical relevance, but they should be interpreted as associations rather than causal effects. Larger prospective multicenter studies in Ethiopia are needed to establish gestational-age-specific reference ranges, investigate nonlinear relationships between UCL and adverse outcomes, and determine whether UCL combined with other placental and cord characteristics can improve identification of pregnancies at increased perinatal risk.

5. Conclusion

This study demonstrated that umbilical cord length among singleton deliveries at Dilla University Referral Hospital was associated with key indicators of fetoplacental growth. Placental weight, birth weight, and gestational age were independently associated with umbilical cord length. Umbilical cord length was also independently associated with fifth-minute Apgar score <7, retained placenta, and stillbirth. These findings suggest that umbilical cord length may provide complementary information about fetal and placental development and selected perinatal outcomes. However, the observed associations do not establish causality, and umbilical cord length should not be interpreted in isolation when assessing perinatal risk.

5.1. Recommendations

Routine documentation of umbilical cord length, together with other cord and placental characteristics, should be considered as part of delivery and perinatal assessment, particularly in cases of stillbirth or neonatal compromise. However, umbilical cord length alone should not currently be used to guide clinical decisions or predict adverse birth outcomes.

Further prospective, multicenter studies with larger sample sizes are recommended to establish gestational-age-specific reference ranges for umbilical cord length in Ethiopia and to investigate nonlinear associations between cord length and adverse perinatal outcomes. Future studies should also assess other cord characteristics, including cord insertion, coiling, knots, entanglement, and number of vessels, alongside maternal, fetal, and placental factors.

6. Strengths and Limitations

6.1. Strengths

This study provides contemporary evidence on umbilical cord length and its associated factors and birth outcomes from Southern Ethiopia, where published evidence remains limited. The study

assessed both determinants of umbilical cord length and its relationship with several maternal and neonatal outcomes within the same study population. Analyzing umbilical cord length as a continuous variable allowed estimation of the change in outcomes associated with each centimeter of cord length. In addition, multivariable regression analyses were used to account for selected potential confounding factors.linear and logistic regression, strengthened the validity of the observed associations.

6.2. Limitations

The cross-sectional design limits causal inference; therefore, the observed associations should not be interpreted as causal relationships. The study was conducted at a single referral hospital, which may limit the generalizability of the findings to other settings in Ethiopia. Several potentially relevant determinants of umbilical cord length, including maternal nutritional status, fetal movement, cord coiling, cord diameter, insertion abnormalities, Wharton's jelly characteristics, and placental vascular morphology, were not assessed. Furthermore, some outcomes, particularly retained placenta and stillbirth, occurred infrequently, resulting in relatively small numbers of events and potentially imprecise effect estimates. Finally, the linear analysis of cord length may not adequately capture potential nonlinear relationships between extreme cord lengths and adverse birth outcomes.

CRediT authorship contribution statement

Mankelklot Kasahun: Conceptualization, Methodology, Investigation, Data curation, Formal analysis, Software, Visualization, Writing – original draft, Writing – review & editing, Project administration. **Abay Mulu**: Conceptualization, Methodology, Supervision, Validation, Investigation, Writing – review & editing, Project administration. **Zelalem Animaw**: Conceptualization, Methodology, Supervision, Validation, Writing – review & editing, Project administration.

All authors reviewed and approved the final version of the manuscript and agreed to be accountable for all aspects of the work.

Data availability statement

The datasets generated and/or analyzed during the current study are not publicly available because they contain information collected from study participants and are subject to institutional and ethical considerations. The data may be made available from the corresponding author, Mankelklot Kasahun, upon reasonable request and subject to approval by the relevant institutional authorities.

Ethical approval

Ethical approval for this study was obtained from the Dilla University Institutional Review Board (IRB) prior to commencement of data collection. The study was conducted in accordance with the ethical principles and relevant guidelines governing research involving human participants. Permission to conduct the study was obtained from the relevant authorities at Dilla University Referral Hospital. Written informed consent was obtained from eligible participants before data collection. Participants were informed about the purpose and procedures of the study, their voluntary participation, and their right to withdraw from the study at any time without consequences. Confidentiality and privacy of participants and their newborns were maintained throughout the study, and all information collected was used solely for research purposes.

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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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Acronyms and abbreviation

AOR	Adjusted odds ratio
APGAR	Appearance, Pulse, Grimace, Activity, Respiration
CI	Confidence interval
NICU	Neonatal intensive care unit
NRFS	Non-reassuring fetal status
PPH	Postpartum hemorrhage
R^2	Coefficient of determination
SD	Standard deviation
SGA	Small for gestational age
SVD	Spontaneous vaginal delivery
UCL	Umbilical cord length
VIF	Variance inflation factor
WHO	World Health Organization
β	Regression coefficient

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