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Research Article

Growth Patterns and Predictors of Poor Growth at Six-Month Chronological Age of Preterm Neonates

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Abstract

Background: The globe receives about 15 million pre-term babies each year, and about two-third of them occur in SubSaharan Africa and South Asia. However, the description of the growth pattern of preterm infants during the first infancy period is still an unmet need in several populations. As a result, this study aimed to describe the growth pattern of preterm babies in the first six months of post-delivery and identify the magnitude of poor growth and its associated factors.

Methods: Institution-based serial cross-sectional study was conducted among 251 eligible pre-term infants selected using a consecutive sampling approach at Ayder Comprehensive Specialized Hospital, Northern Ethiopia, from September 2017 to August 2019. Data were extracted using extraction format from charts of the preterm neonates, registration books and electronic records. After entering data into EpiData 4.4 and then it was exported to SPSS version 23 for analysis. Frequencies and percentages were used to describe categorical variables. Continuous variables were also described using an appropriate combination of measure of central tendency and measure of dispersion. Adjusted odds ratios, 95% confidence intervals, and P-values were computed by conducting logistic regression, to evaluate the association of predictors with poor growth. A p-value less than 0.05 were considered statistically significant.

Results: Male neonates constitute 58.2% of the study participants. Very preterm, moderate preterm, and late preterm accounted for 19.1%, 33.9%, and 47.0% of the study participants. Very low birth weight accounted for 191 (76.1%) of the preterm infants. The median length of stay in the neonatal ICU was 11 days. The mean duration of admission in neonatal ICU was 14.9 (SD = 10.0) days, while days needed to regain birth weight was 13.2 (SD = 5.4) days. The average daily weight gain velocity was 9 g/kg/day in the first month. Fifty-one percent of preterm infants had poor growth at least with one parameter (17.5% of infants by weight, 38.6% by length, 22.7% by HC, and 3.6% by weight for length) being less than -2 z-score. As birth weight increases by 1 kilogram, the odds of poor growth were found to decrease by 94% [AOR = 0.06; 95% CI: 0.02 to 0.18); $p < 0.001$].

Conclusion: The incidence of poor growth at six months among preterm-born infants in our study population was high. Lower birth weight was found to be a statistically significant independent risk factor for poor growth.

Keywords: *Growth Pattern; Preterm; Neonate; Poor Growth; Weight; Height, Head Circumference*

Abbreviations

ACHS: Ayder Comprehensive Specialized Hospital; HBsAg: Hepatitis B Surface Antigen; HC: Head Circumference; HC/A: Head Circumference for Age; ICU: Intensive Care Unit; KMC: Kangaroo Mother Care; L/A: Length for Age; PDA: Patent Ductus Arteriosus; PITC: Provider Initiated Testing and Counseling; VDRL: Venereal Disease Research Laboratory; W/A: Weight for Age; W/L: Weight for Length; WHO: World Health Organization

Introduction

Poor growth in preterm infants is a significant concern, as it is associated with adverse immediate health outcomes and long-term neurodevelopmental impairments. These infants have an increased risk of morbidity and mortality, including interventricular hemorrhage (IVH), respiratory distress syndrome (RDS), and necrotizing enterocolitis (NEC), which can further impact their growth and overall prognosis [1,2].

Globally, about 13.4 million babies are born before term every year, and approximately 65% of these preterm births occur in Sub-Saharan Africa and South Asia [3]. Beyond the neonatal period, the adequate growth of preterm infants continues to reflect and influence their overall health status. This is because prematurity and fetal malnutrition predispose to childhood undernutrition, infections, and other morbidities [4]. Infants born before 37 weeks of gestational age have over the 2fold risk of growth faltering in early childhood, with possible impacts on their neurodevelopment [5]. A multicenter, population based longitudinal study conducted across eight geographically defined populations in both LMICs and developed countries, focusing on postnatal growth in preterm infants, showed that the very preterm subgroup experienced growth flattening in the first few weeks after birth, but weight gain was linear for babies born after 32 weeks' gestation [6].

A growing body of evidence indicates that fetal and infant growth has profound, lasting consequences for a person's health throughout their life course; nevertheless, there is inadequate information on preterm infants, a susceptible population at risk for growth and development abnormalities [7]. In Ethiopia, information regarding patterns of preterm babies' growth during the postnatal period is quite limited.

Aim of the Study

This study aimed to assess the growth patterns of preterm infants and the magnitude of poor growth and identify predictors of poor growth at six months in Ayder Comprehensive Specialized Hospital (ACSH), Mekelle, Northern Ethiopia.

Materials and Methods

Study area and period

This study was conducted in ACSH, a tertiary care hospital found in Tigray region, the northern part of Ethiopia. It is the biggest referral hospital in the Tigray region of Ethiopia. It started as a referral medical center in 2008 to nine million populations in the catchment areas of Tigray, Afar and the Southeastern part of Amhara regions [8]. The department of pediatrics and child health has four major wards, pediatric intensive care unit (ICU), forty bed capacity neonatal ICU with KMC room. During this period, the hospital's bed-occupancy rate ranged from 82% to 109%. It also has a general and five subspecialty outpatient clinics and an emergency room with an average of six beds. This study was conducted between May 2021 and April 2022.

Study design

A serial cross-sectional study was employed on neonates born prematurely and admitted to neonatal ICU from September 1, 2017 to August 31, 2019.

Population

The source population was preterm neonates (born < 37 weeks gestational age) who had been admitted to neonatal ICU at ACSH. The study population includes preterm neonates who had been admitted to neonatal ICU and discharged with linkage to high-risk infant's follow-up clinic at ACSH with 6th month follow-up information.

Ethical clearance

Ethical clearance was obtained from the Institutional Review Board (IRB) of the College of Health Sciences of Mekelle University. A support letter from the chief clinical director was also obtained before the commencement of the study. In addition, all the information collected from the study subjects was handled confidentially by De-identifying the unique identifiers.

Eligibility criteria

We included preterm infants with at least four visits in the first six months' follow-up period, including the 6th month chronological age. Preterm infants with gross congenital malformations (craniofacial malformations and complex congenital heart disease) were excluded from the study.

Sample size determination and sampling procedure

A total of 497 preterm neonates have been linked to neonatal ICUs to the follow-up clinic between September 2017 and August 2019. Of whom, 124 (25.0%) subjects didn't attend the 6th-month postnatal age follow-up, 88 (17.7%) subjects had incomplete records, and 34 (6.8%) charts were not found. Two hundred fifty-one (50.5%) of the study population fulfilled the inclusion criteria and were enrolled serially into the study (Figure 1).

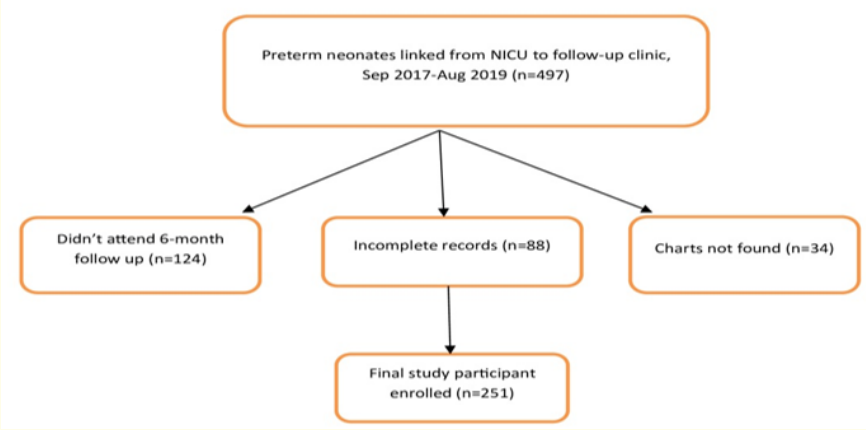

Figure 1: *Study flow diagram of eligible population and participants included in the analysis, ACSH, September 2017-August 2019.*

Variables

The outcome variable was preterm postnatal growth pattern and status. Independent variables were sociodemographic characteristics (age of the mother, sex, marital status, and occupation), pregnancy risks (preeclampsia and multiple gestations), mode of delivery, gestational age at delivery, preterm associated complication (sepsis, hypothermia, PDA, jaundice, apnea, and necrotizing enterocolitis), birth weight, length and head circumference (HC), time to reach full volume feeds, time to regain birth weight, length of ICU stay, exclusive breastfeeding.

Measurements and definition of terms

- **Growth pattern**: The trajectory of an individual child's anthropometric measurements (e.g. weight-for-age, height-for-age, HC-for-age) as plotted over time.
- **Corrected age:** For premature infant born "n" weeks before term, correction of postnatal age is made by subtracting "n" weeks from the postnatal age.
- **Overall poor growth:** A growth measurement <-2 z-score as per the WHO growth standards with at least one of weight for age (W/A), length for age (L/A), head circumference for age (HC/A), or weight for length (W/L) after correction of age done at six-month chronological age.
- **Late preterm:** Born between 34 and 36 completed weeks of pregnancy.
- **Moderate preterm:** Born between 32 to less than 34 weeks of pregnancy.
- **Very preterm**: Born between 28 to less than 32 weeks of pregnancy.
- **Extreme preterm:** Born less than 28 weeks of pregnancy.
- **Morphometry:** Weight was measured by digital scale. Length was measured using a tape meter which is placed at the top of the infants head, stretching infant's legs out to ensure accurate length. The head circumference measurement was done using a tape meter around the most prominent part of the occiput and the supraorbital area, but above the supraorbital ridges. All measurements were made by an experienced pediatric nurse assisted by trained residents.
- **Full volume feeds**: A preterm neonate is said to have reached full volume feeds when the total daily amount of enteral feeding reached at least 80 ml/kg on day one, 100 ml/kg on day two, 120 ml/kg on day three, 140 ml/kg on day four, 160 ml/kg on day five, 180 ml/kg on day six and beyond.
- **Sun exposure status:** sufficient sunlight exposure was considered as those infants exposed to sunlight daily in the morning session a minimum of 15 to 30 minutes. This will be documented as optimal or suboptimal based on the documentation of the treating physician.
- **Ballard score:** Trained residents performed the Ballard score within 48 hours of birth. The item-wise raw score, total physical score, total neurological score, total score, and GA based on the total score were recorded.
- **Feeding practice:** The feeding approach we take depends on the patient's condition. Generally, we provide either oral feeding or expressed breast milk from the mother. If this is not possible, we consider using a preterm formula, depending on its availability and affordability. As a last resort, we may use infant formula, which is commonly used for most infants. The use of donor breast milk and fortification is not practiced in our context. Donor breast milk and fortification are not practiced in our context.

Data collection method and procedure

An extraction format was adopted from different works of literature [9-14] and the registration book; it was then used to collect data regarding sociodemographic and health-related factors**.** Data were also extracted and collected from the preterm infants' charts, registration books, and Electronic Medical Records (EMR). Data collection was undertaken by medical interns and residents.

Data analysis

The collected data were first coded and entered into EpiData version 4.4; it was then exported to SPSS version 23 for analysis. Data were checked for consistency and completeness, then cleaned and edited prior to performing analysis. The following were the main analysis that were conducted.

Descriptive statistics

Descriptive statistics were conducted on the data set to recognize the mean gestational age, birth weight, length, and HC. In addition, the average time required to regain birth weight and to reach full volume feeds, mean duration of hospital stay, and average mean monthly weight, length, and HC gains were analyzed using frequency and percentage. First-month weight gain velocity (g/kg/day) was obtained by dividing the monthly mean weight gain (gram) to mean weight (kg) in one month. Temporal changes in body weights, length, and HC during the followup period are presented graphically. Tables and figures were used for the outputs of the descriptive statistics. Z-score growth measurement at six months chronological age for W/A, L/A, HC/A, and W/L after correction of age was done using the WHO anthro package of R statistical software [15].

Bivariate and multivariable analysis

Binary logistic regression analysis was conducted to identify factors associated with poor growth. Independent variables were computed with crude odds ratio (COR) then variables with $P < 0.05$ were fitted in the final adjusted odds ratio (AOR). In the multivariable regression analysis, independent variables with $P < 0.05$ were considered independent predictors of poor growth at a six-month chronological age.

Model fitness and multicollinearity

The multivariable logistic regression model was a good fit for the data (Hosmer-Lemeshow test: $c2 = 5.08$, $df = 8$, $p = 0.749$) and had no problem with multicollinearity (max VIF = 8.912, mean VIF = 4.204).

Data quality

Data were collected by medical interns and pediatric residents, and training was given regarding the checklist, data collection technique, and confidentiality. Afterwards, the data collectors were supervised in situations where they had some concerns about the data. The collected data were checked for completeness, consistency, and clarity on the same day of data extraction.

The measurements of the growth parameters were conducted by 2 trained nurses who were exclusively assigned to follow up clinic. Maximum effort was made to grab accurate data.

Result

Sociodemographic characteristics and healthcare utilization of the mother

More than half (56.2%) of the mothers were in the age group 26 - 35 years. All participant mothers were married and from Tigray. Among them, the most common occupation was housewife (82.5%). All of them had antenatal care visits, and institutional delivery accounted for the vast majority of the participants (96.4%). About three out of five (62.5%) neonates were delivered via spontaneous vaginal delivery (SVD) (Table 1).

Variable	Category	Frequency, n = 251	Percent (95% CI)
Age of the mother	18-25	90	35.9 (29.5, 42.2)
	26-35	141	56.2 (49.8, 62.5)
	>35	20	8.0 (4.9, 11.6)
Marital status	Married	251	100 (100, 100)
Occupation	Housewife	207	82.5 (77.3, 87.3)
	Government employee	32	12.7 (8.5, 16.7)
	Merchant/self-employed	11	4.4 (2.0, 7.2)
	Daily laborer	1	0.4 (0.0, 1.2)

Antenatal care visit (At least 1 visit)	Yes	251	100 (100, 100)
	No	0	0.00%
Place of delivery	Hospital	225	89.6 (85.7, 92.8)
	Health center	17	6.8 (4.1, 9.6)
	Home	9	3.6 (1.6, 6.2)
Screening	Total screened	251	100 (100, 100)
	PITC reactive	3	1.2 (0.0, 2.8)
	VDRL reactive	1	0.4 (0.0, 1.2)
	HBsAg reactive	15	6 (3.3, 9.6)
Mode of delivery	SVD	157	62.5 (57, 68.5)
	Caesarean section	94	37.5 (31.5, 43)

Table 1: *Sociodemographic characteristics and healthcare utilization of the mother, ACSH, September 2017-August 2019, n = 251. SVD = Spontaneous Vaginal Delivery, PITC = Provider-Initiated Testing and Counseling, VDRL = Venereal Disease Research Laboratory, HBsAg = Hepatitis B Surface Antigen.*

Baseline features of the preterm infants

Male neonates constitute 58.2% of the study participants. Very preterm, moderate preterm, and late preterm accounted for 19.1%, 33.9%, and 47.0% of the study participants. Low birth weight accounted for 191 (76.1%) of the preterm infants. The gestational age of the preterm-born neonates was calculated based on the last normal menstrual period for more than half (51.8%) of them, while the rest was according to early ultrasound and Ballard score. The magnitude of multiple pregnancy was 70 (27.9%). Only 114 (45.4%) mothers of the neonates received prophylactic corticosteroids, among which more than half (52.6%) took only a single dose.

The type of feeding started for 218 (86.9%) of neonates was breast milk, 24 (9.6%) infant formula, and only 6 (2.4%) preterm formula. About three-quarters (74.1%) of the preterm neonates started Kangaroo Mother Care (KMC) during admission. Only 136 (54.2%) participants were given iron supplementation while none of them were provided with other micronutrients (vitamin D, calcium, phosphorus, zinc, sodium). Vaccination was started for all neonates. Regarding sunlight exposure, only one out of five (21.9%) preterm neonates got optimal sunlight exposure (Table 2).

Variable	Category	Frequency, n = 251	Percent (95% CI)
Sex of child	Male	146	58.2 (51, 64.1)
	Female	105	41.8 (35.9, 49)
Gestational age	Very preterm	48	19.1 (14.5, 24.2)
	Moderate preterm	85	33.9 (28.4, 40.2)
	Late preterm	118	47.0 (41, 52.6)
Birth weight	Extremely low birth weight	04	1.6 (0.4, 3.5)
	Very low birth weight	51	20.3 (15.3, 25.8)
	Low birth weight	191	76.1 (70.5, 81.7)
	Normal birth weight	05	2.0 (0.4, 3.9)
Method gestational age calculated	Reliable LNMP	130	51.8 (45.4, 58.4)
	Ballard score	108	43 (36.4, 49.4)
	Early ultrasound	13	5.2 (2.4, 8.5)

Number of fetus during gestation	Singleton	181	72.1 (66.1, 77.6)
	Twin	55	21.9 (17.1, 27.8)
	Triplet	15	6.0 (3.6, 9.2)
Corticosteroid use	Yes	114	45.4 (39.2, 53.3)
	No	128	51.0 (43.8, 56.8)
	Unknown	09	3.6 (1.6, 6.4)
Corticosteroid dose (n = 114)	Full course	31	27.2 (20.2, 34.8)
	Half course	23	20.2 (13.2, 27.2)
	Stat dose	60	52.6 (44.7, 61.4)
Type of feeding started	Breast milk	218	86.9 (82.2, 90.8)
	Preterm formula	06	2.4 (0.8, 4.8)
	Infant formula	24	9.6 (5.7, 13.1)
	Mixed breast and formula	03	1.2 (0.0, 3.1)
KMC	Yes	186	74.1 (67.9, 78.5)
	No	65	25.9 (21.5, 32.1)
Iron supplementation	Yes	136	54.2 (47.5, 59.8)
	No	115	45.8 (40.2, 52.5)
Sunlight exposure	Optimum	55	21.9 (17.1, 27.5)
	Suboptimum	196	78.1 (72.5, 82.9)

***Table 2**: Baseline features of the preterm infants, ACSH, September 2017-August 2019, n = 251.*

KMC = Kangaroo Mother Care, LNMP = Last Normal Menstrual Period.

The top five co-morbidities during admission in the preterm neonates were hypothermia (83.3%), suspected sepsis (82.1%), jaundice (44.1%), hyaline membrane disease (29.9%), and culture proven sepsis (17.5%) (Figure 2). Among those with suspected sepsis, blood culture was done for only 60 (29.1%), of which 36/60 (60%) of them were found to show growth of microorganisms.

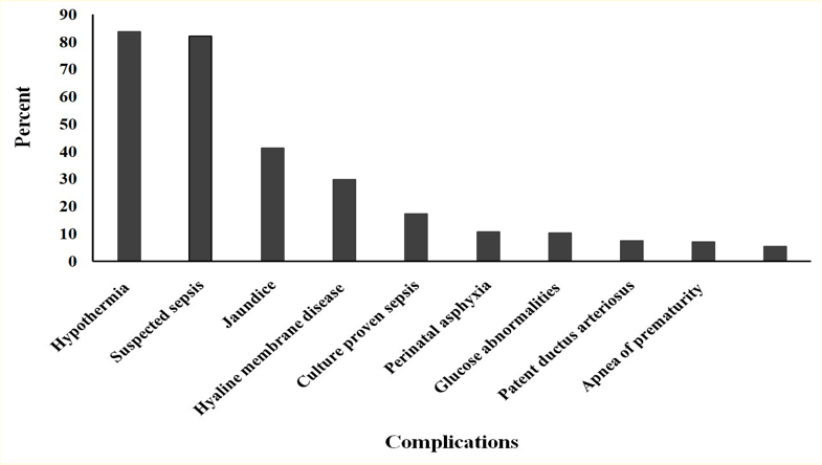

***Figure 2:** Percentage preterm complications during neonatal admission, ACSH, September 2017-August 2019, n = 251.*

Birth measurement and growth patterns of the preterm infants

The median gestational age at birth was 33.0 weeks (IQR: 32.0 - 35.0; 25th - 75th percentiles). The median age of neonate at admission was 1 hour with an interquartile range (IQR) of 2.3 minutes. The median length of stay in the neonatal ICU was 11 days. The median time needed to reach full volume feeds was 5 (IQR = 4) days. The average time the preterm neonates regained their birth weight was by the end of second week. The median birth weight, length, and head circumference were 1800g (IQR: 1500 - 2000), 42.0 cm (IQR: 40.0 - 44.0), and 31.0 cm (IQR: 30.0 - 32.0), respectively. The peak mean weight and length gain was in the third month (986.2 - 252.0 grams and 4.1 - 0.9 cm respectively), while peak mean HC growth was noted in the second month (2.3 - 0.5). The average daily weight gain velocity was 9.0 (95% CI: 8.6, 9.8) g/kg/day in the first month. The average mean monthly weight, length, and HC gain was 806.9 - 119.8 grams, 3.3 - 0.6 cm, and 1.7 - 0.2 cm, respectively, in the first six months (Table 3).

Variable	Mean	SD/IQR	(Min, Max)
Gestational age (weeks)	33.3	2.1	(28, 36)
Age of neonate at admission (hours)	1.00[a]	2.3[b]	(0.2, 216)
Average length of stay (days)	14.9	10.0	(3, 48)
Days needed to reach full feeding (n = 250)	5.00[a]	4.00[b]	(1, 23)
Days needed to regain birth weight (n = 247)	13.2	5.4	(1, 35)
Frequency of feeds per day	11.8	1.4	(8, 16)
Birth Weight (gram) Length (cm) HC (cm)	1756.8 42.1 30.9	369.7 3.3 2.0	(920, 2930) (34, 52) (25, 35)
1 Mo Weight (gram) (n = 249) Length (cm) (n = 239) HC (cm) (n = 249)	 2230 44.9 32.9	 508.8 3.3 2.0	 (1070, 4500) (35, 55) (28, 37)
2 Mo Weight (gram) (n = 250) Length (cm) (n = 236) HC (cm) (n = 250)	 3179 48.8 35.2	 632.7 3.5 2.0	 (1600, 5500) (37, 58) (29, 39)
3 Mo Weight (gram) (n = 248) Length (cm) (n = 237) HC (cm) (n = 249)	 4166.7 52.9 37.3	 724.6 3.6 1.8	 (2300, 6900) (42, 60) (32, 41)
4 Mo Weight (gram) (n = 247) Length (cm) (n = 226) HC (cm) (n = 247)	 5067.2 56.4 38.9	 759.6 3.6 1.7	 (2800, 7600) (46, 64) (34, 45)
5 Mo Weight (gram) (n = 247) Length (cm) (n = 223) HC (cm) (n = 247)	 5876.0 59.2 40.0	 795 3.7 1.6	 (3200, 8000) (47, 67) (36, 46)
6 Mo Weight (gram) Length (cm) HC (cm)	 6612.2 61.7 41.0	 845.1 3.7 1.6	 (3600, 8500) (48, 69) (37, 47)
Average monthly weight gain	806.9	119.8	(392.5, 1067.5)

Average monthly length gain (n = 247)	3.3	0.6	(1.3, 5.0)
Average monthly HC gain	1.7 0.2		(1.0, 2.7)

Table 3*: Healthcare utilization and growth measurements of the preterm infants, ACSH, September 2017-August 2019, n = 251.*

[a]: Implies median and [b]: Implies interquartile range (IQR) for variables with skewed distribution.

SD = Standard Deviation, Min = Minimum, Max = Maximum, Mo = Month, cm = Centimeter, HC = Head Circumference.

The average weight of male participants was higher than female participants throughout the growth pattern. At six-month chronologic age, 17.5% of infants had poor growth by weight (W/A < -2 z-score) according to WHO growth curves. At six-month chronologic age, 38.6% of infants had poor growth by length (L/A < -2 z-score) according to WHO growth curves. Males had higher average birth and monthly HC measurements than their female counterparts. At six-month chronologic age, 22.7% of infants had poor growth by HC (HC/A < -2 z-score) according to WHO growth curves (Figure 3 and table 4).

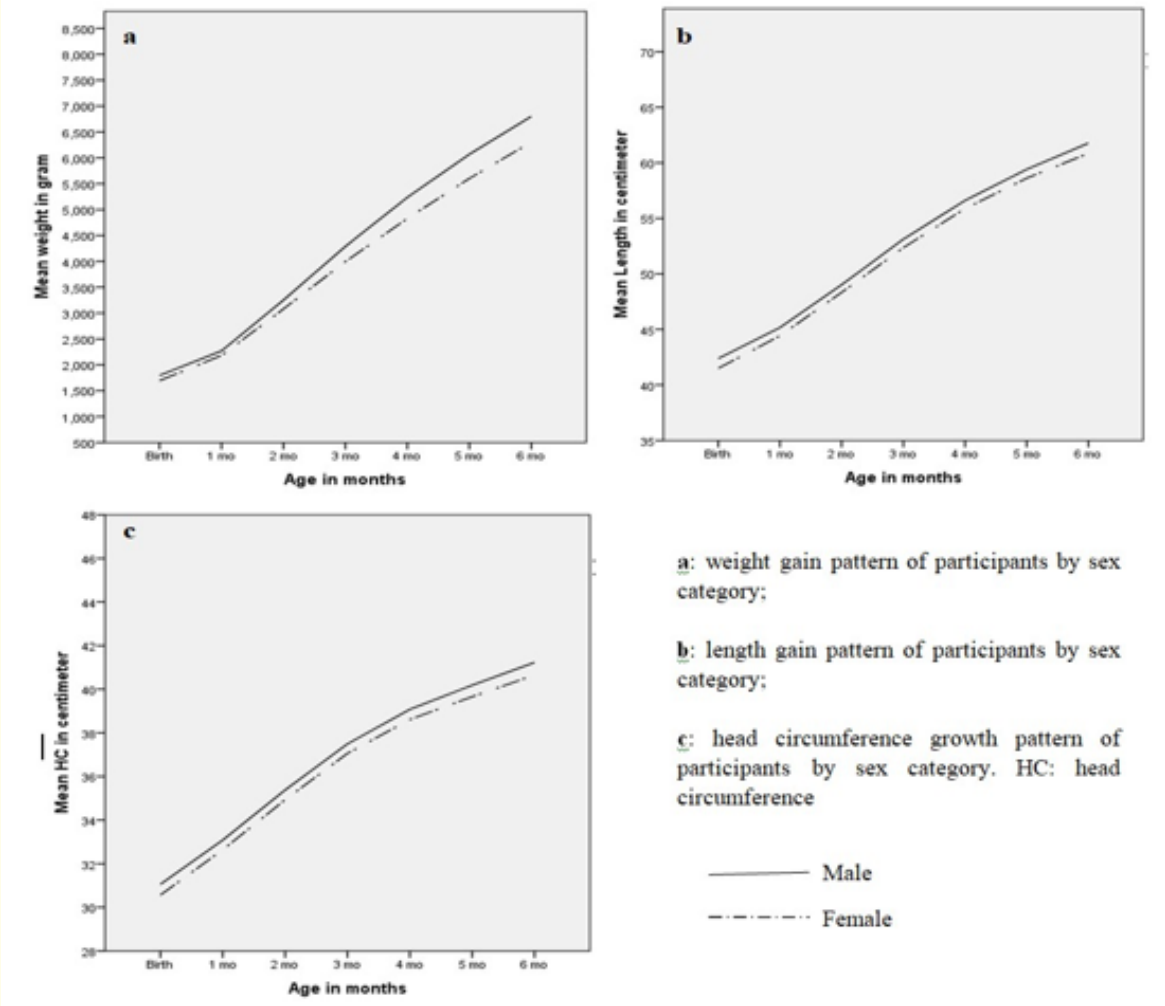

Figure 3: *Growth patterns at six-month chronological age of preterm neonates, ACSH, September 2017-August 2019, n = 251.*

Growth status at six-month chronologic age of the preterm infants

Assessment of growth status at six-month chronologic age was done according to WHO growth standards for corrected age. Accordingly, more than half 51.0% (95% CI: 44.2, 57.4) of infants had poor growth at least with one parameter (17.5% of infants by weight, 38.6% by length, 22.7% by HC, and 3.6% by weight for length) being less than -2 z-score (Table 4).

Variable	Category	Frequency, n = 251	Percent (95% CI)
Length WHO z-score	Less than -3	58	23.1 (18.3, 28.7)
	-3 up to -2	39	15.5 (10.8, 19.5)
	-2 up to 2	154	61.4 (55.9, 66.9)
Weight WHO z-score	Less than -3	10	4.0 (1.6, 7.0)
	-3 up to -2	34	13.5 (8.8, 18.3)
	-2 up to 2	207	82.5 (76.5, 87.3)
HC WHO z-score	Less than -3	15	6.0 (2.8, 8.8)
	-3 up to -2	42	16.7 (12.7, 21.5)
	-2 up to 2	193	76.9 (71.3, 81.3)
	Above 3	1	0.4 (0.0, 1.6)
WFL Z-score	Less than -3	2	0.8 (0.0, 2.0)
	-3 up to -2	7	2.8 (0.8, 5.2)
	-2 up to 2	213	84.9 (80.5, 89.2)
	2 up to 3	14	5.6 (2.8, 9.2)
	Above 3	15	6 (3.2, 8.8)
Growth status by weight at 6 Mo chronologic age	Good	207	82.5 (78.5, 88.0)
	Poor	44	17.5 (12.0, 21.5)
Growth status by length at 6 Mo chronologic age	Good	154	61.4 (54.7, 67.6)
	Poor	97	38.6 (32.4, 45.3)
Growth status by HC at 6 Mo chronologic age	Good	194	77.3 (71.7, 82.3)
	Poor	57	22.7 (17.7, 28.3)
Growth status by WFL at 6 Mo chronologic age	Good	242	96.4 (94.1, 98.4)
	Poor	9	3.6 (1.6, 5.9)
Overall growth status	Good	123	49.0 (42.6, 55.8)
	Poor	128	51.0 (44.2, 57.4)

Table 4*: Sixth month growth pattern and status of the preterm infants, ACSH, September 2017-August 2019, n = 251.*

WHO = World Health Organization, HC = Head Circumference, WFL = Weight for Length, Mo = Month.

Predictors of poor growth

Predictors of poor growth at six-month chronologic age among preterm infants were identified by conducting binary logistic regression. Six variables (gestational age, duration of neonatal ICU stay, days needed to reach full volume feeding, days needed to regain birth weight, gestational age category, and birth weight) were significant upon conducting bivariate analysis. During multivariable analysis, one variable was identified as an independent predictor of poor growth at six-month chronologic age. As birth weight increases by one kilogram, the odds of poor growth decreases by 94% (AOR = 0.06, $p < 0.001$) (Table 5). The multivariable logistic regression model was a good fit for the data (Hosmer-Lemeshow test: $c2 = 5.08$, $df = 8$, $p = 0.749$) and had no problem of multicollinearity (max VIF = 8.912, mean VIF = 4.204).

Predictors	COR [95% CI]	p-value	AOR [95% CI]	p-value
Gestational age (weeks)	0.76 (0.67, 0.87)	<0.001	0.87 (0.57, 1.33)	0.531
Gestational age category				
Very preterm	3.67 (1.79, 7.56)	<0.001	0.24 (0.03, 2.03)	0.192
Moderate preterm	1.87 (1.06, 3.29)	0.030	0.64 (0.21, 1.99)	0.437
Late preterm	1		1	
Duration of neonatal ICU stay(days)	1.05 (1.02, 1.08)	<0.001	1.01 (0.96, 1.06)	0.621
Days needed to reach full volume feeds (n = 250)	1.15 (1.06, 1.26)	0.001	1.03 (0.91, 1.17)	0.651
Days needed to regain birth weight (n = 247)	1.08 (1.02, 1.14)	0.005	1.03 (0.96, 1.10)	0.422
Birth weight (kg)	0.07 (0.03, 0.16)	<0.001	0.06 (0.02, 0.18)	<0.001

Table 5*: Predictors of poor growth at six-month chronologic age, ACSH, September 2017-August 2019, n = 251.*

ICU = Intensive care unit, kg = Kilogram, AOR = Adjusted Odds Ratio, COR = Crude Odds Ratio.

Discussion

This study set out to describe growth pattern among preterm infants, determine magnitude of poor growth at six-months of age, and identify factors associated with poor growth. Accordingly, the mean time the preterm infants regained their birth weight was at 13.2 days. The median time needed to reach full-volume feeds was 5 days. The average growth velocity of preterm neonates was 9.0 g/kg/day in the first month. Our study found the magnitude of poor growth at six months of 51.0%, and low birth weight was identified as an independent predictor of poor growth.

The mean time the preterm infants achieved their birth weight was by the end of the second week, which was consistent with earlier reports [16,17]. The initial body weight reduction in the early neonatal period is mainly due to physiologic loss of body fluid in newborns, which may be more marked in preterm infants [18].

The weight gain velocity in preterm infants in this study was 9.0 (95% CI: 8.6, 9.8) g/kg/day which is slightly lower than a report from Nigeria, which was 11.2 g/kg/day [16] despite their relatively lower mean gestational age (31.3 - 2.4 weeks) and birth weight (1510.8 ± 347.5g). This difference could be due to the longer average length of stay in our study (14.9 days), compared to the previous study (7.1 days). The longer duration of admission in neonatal ICU could be due to unresolved complications and the need for stability that implies the quality of care; as a result, the neonates would be prone to maintenance fluid rather than direct enteral feeding. Similarly, the growth velocity in our study was much lower than a study finding conducted in Cameroon, 17.35 g/kg/day [19].

In a couple of different studies done in India, growth charts showed a growth velocity of 15.18 g/kg/day [20] and 16.24 g/kg/day [16]. The higher value in the first study could be due to the use of a human milk fortifier for the preterm neonates, unlike in our setup. Mathew., *et al.* reported that the preterm infants had a higher speed of growth than ours, despite their lower birth weight (1226.7g) and prolonged time (8.6 days) needed to reach full-volume feeds. This higher speed of weight gain could be for two reasons. First, it could be because of calculating the growth velocity from the day the preterm neonates regained birth weight excluding the early neonatal period when growth velocity is negative. Second, the study used higher feeding volumes of 200 ml/kg/day. Although enteral feeding with human milk is the optimal feed for newborns due to its caloric and immunologic constituents, their immaturity may hinder adequate oral intake [21]. Consequently, partial parenteral nutrition may be beneficial in preterm low-birth-weight infants during the early neonatal period [22].

However, advanced nutritional supports were not readily available in our center, and none of our participants received total parenteral nutrition.

Despite differences in the definition of postnatal growth failure reference standards used and the population studied, postnatal growth failure is a universal problem in preterm infants. Our study found a magnitude of poor growth to be 51% (95% CI: 44.2%, 57.4%) among surviving preterm infants who had a follow-up in ACSH, based on the definition of poor growth as a WHO z-score <-2 for corrected postnatal age with at least one of the parameters: W/A, L/A, HC/A, and W/L.

In our study, after adjusting for confounding variables, lower birth weight remained a significant independent risk factor for poor growth at 6 months. This aligns with findings from Korea [13] and the U.S. [14]. Another multicenter cohort study in the U.S found that over 90% of infants < 1000g experienced postnatal growth failure, influenced by factors like sepsis, ventilation, and inadequate nutrition [23]. The high rate of poor growth in our setting may reflect limited lactation support, lack of TPN, and the inclusion of high-risk neonates with prolonged hospital stays.

Limitations of the Study

This study has some limitations. Data were missing on most medical charts, especially length, in a significant number of our study population. A quarter of them were twins, which could contribute to a poor growth pattern as managing/feeding twins in the Ethiopian context could be challenging.

A notable limitation in this study also includes the unassessed parameters such as type of feeding throughout the study period, hospital admissions and the mother's nutritional status. Considering these variables in future research could provide a better understanding of patient outcomes.

This study is limited by the lack of illness severity data, such as SNAPPE scores. Future studies should incorporate standardized severity scoring system to better characterize patient outcome.

Conclusion

The incidence of poor growth at six-months among preterm born infants in our study was high. Aggressive effort to introduce new nutritional strategies that will improve the nutritional status of prematurely born neonates is desirable. Enteral feeding should be started as early as possible in preterm infants admitted to neonatal ICU. Micronutrient supplementation for preterm infants should be routine practice by healthcare providers and easy access should be ascertained by hospital administration and regional health bureau.

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Authors' Contributions

S.N.W. had taken a principal role in the conception of ideas, writing the protocol, developing methodologies, analyses and write-up of the article and drafted the manuscript. A.L.W. had higher role in selecting the title and contributed to the write up of the study. A.H.B. and M.Y.H. contributed to the write up of the study and made revision to the paper as clinical advisors. M.W.G. took his part in developing methodologies and made a critical revision to the paper and manuscript for intellectual content. H.E.A. and M.M.E. took their part on data analysis and write up of the study. K.M.T. contributed to data management and analysis. K.W.G., S.M.F., D.S.G., M.M.M., and AAM made a critical revision to the paper and manuscript. All the authors read and approved the final manuscript.

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Availability of Data and Materials

The datasets used and/or analysed during the current study available from the corresponding author on reasonable request.

Ethics and Consent to Participate Declarations

Due to retrospective nature of the study, Institutional Review Board (IRB) of Mekelle University waived the need of obtaining informed consent.

Ethics Approval

Ethical clearance was obtained from IRB of the College of health sciences of Mekelle University with IRB number of MU-IRB 1865/2021. Support letter from chief clinical director was also obtained before the commencement of the study. Moreover, it confirms that this study compiles all the requirements of the latest 2013 version of the Declaration of Helsinki.

Competing Interests

The authors declare that they have no competing interests.

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Volume 15 Issue 8 August 2026