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Nutritional care for low birth weight infants delivered in Gadarf teaching hospital from January – June 2024 (Sudan).

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ABSTRACT

Low birth weight (LBW) is a significant public health challenge linked to increased neonatal morbidity, mortality, and long-term developmental issues. This study examines the nutritional care and growth patterns of LBW infants born at Gadarf Teaching Hospital, Sudan, from January to June 2024, with a follow-up period of six months. A longitudinal, facility-based approach was used to assess infant feeding practices, maternal nutrition, and health outcomes.

The findings reveal that while exclusive breastfeeding was common, many infants received formula feeding due to various maternal and socioeconomic factors. Despite efforts to promote optimal nutrition, a considerable number of LBW infants did not reach standard growth milestones, with many experiencing stunted growth and undernutrition. Delayed breastfeeding initiation and early introduction of complementary foods negatively impacted growth patterns. Socioeconomic factors such as maternal education, household income, and healthcare accessibility played a critical role in determining neonatal nutritional status.

Additionally, hospital readmission rates were notable, with respiratory distress, infections, and feeding difficulties being common causes. Many infants missed follow-up visits due to financial constraints, lack of awareness, and transportation issues, further contributing to poor growth outcomes.

This study highlights the urgent need to improve maternal nutrition, promote exclusive breastfeeding, and enhance postnatal care services. Strengthening community-based healthcare programs, increasing awareness of optimal infant feeding practices, and ensuring accessible healthcare can significantly improve neonatal outcomes. Addressing these challenges through targeted interventions and policy reforms is essential in reducing neonatal mortality and promoting healthy development in LBW infants.

Keywords: Low Birth Weight (LBW), Neonatal Nutrition, Infant Growth Outcomes, Maternal Health, Postnatal Care

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INTRODUCTION

Birth weight is a critical determinant of neonatal health and survival, serving as an essential indicator of fetal growth and maternal well-being. According to the World Health Organization (WHO), low birth weight (LBW) is defined as a birth weight of less than 2,500 grams (5.5 pounds), regardless of gestational age **(WHO, 2014)**. LBW is not a homogeneous outcome but rather a result of multiple factors, including preterm birth (birth before 37 completed weeks of gestation) and intrauterine growth restriction (IUGR), which refers to inadequate fetal growth during pregnancy **(WHO, 2004).**

Globally, LBW remains a significant public health concern due to its association with increased neonatal mortality, morbidity, and long-term developmental complications. Neonates with LBW are at a higher risk of perinatal asphyxia, respiratory distress syndrome (RDS), hypoglycemia, infections, and feeding difficulties **(Bhaskar et al., 2015).** Moreover, LBW is linked to long-term health implications, including impaired cognitive development, poor school performance, and an increased risk of chronic diseases such as hypertension and diabetes later in life **(Hughes, Black & Katz, 2017).**

In Sudan, particularly in resource-limited settings such as Gadarf Teaching Hospital, the burden of LBW is substantial. The availability of specialized neonatal care, adequate maternal nutrition, and proper postnatal follow-up remains a challenge. Therefore, investigating the nutritional care and feeding practices of LBW infants is crucial to improving neonatal outcomes and reducing the associated risks. This study aims to assess the nutritional care, growth patterns, and health outcomes of LBW infants delivered at Gadarf Teaching Hospital, Sudan, between January and June 2024, with a follow-up period of six months.

The prevalence of LBW varies globally, with developing countries experiencing a higher incidence due to factors such as maternal malnutrition, infections, adolescent pregnancies, and inadequate prenatal care **(UNICEF & WHO, 2004)**. According to the UNICEF-WHO Joint Database, approximately 15% of newborns worldwide are classified as LBW, with the highest rates observed in South Asia (28%) and Sub-Saharan Africa (14%) **(WHO, 2019).**

Causes of Low Birth Weight

LBW can result from a combination of maternal, fetal, and environmental factors:

1-Maternal Factors:

- Poor maternal nutrition before and during pregnancy significantly influences fetal growth and birth weight. Malnutrition and micronutrient deficiencies (e.g., iron, folic acid, and zinc) have been strongly linked to LBW **(Roland et al., 2014).**
- Teenage pregnancies (≤19 years) and advanced maternal age (>35 years) are associated with an increased risk of LBW due to inadequate uterine growth and placental insufficiency **(Melekoğlu & Saraç, 2022).**
- Maternal infections, including malaria, syphilis, HIV, and urinary tract infections, contribute to LBW by inducing intrauterine inflammation and fetal growth restriction **(Sharma & Shastri, 2016).**
- Maternal lifestyle factors, such as smoking, alcohol consumption, and excessive physical labor, can lead to poor fetal development and premature birth **(Bhaskar et al., 2015).**

2-Fetal and Placental Factors:

- Multiple pregnancies (e.g., twins, triplets) increase the likelihood of LBW due to limited intrauterine space and nutrient sharing between fetuses **(Johnson, Jones & Paranjothy, 2017).**
- Congenital anomalies and intrauterine infections, such as cytomegalovirus and rubella, can impair fetal growth and development **(ACOG, 2000).**

- Placental insufficiency, caused by conditions such as pre-eclampsia, placental abruption, and placenta previa, can restrict nutrient and oxygen supply to the fetus, leading to LBW **(Villar et al., 2012).**

Socioeconomic and Environmental Factors:

- Low birth weight is strongly associated with poverty, inadequate prenatal care, and poor maternal education. Women from low-income backgrounds are more likely to have poor access to healthcare, inadequate nutrition, and higher levels of stress, all of which increase the risk of LBW **(WHO & UNICEF, 2004).**
- Environmental pollutants, including indoor air pollution, exposure to biomass fuels, and poor housing conditions, have been identified as contributing factors to fetal growth restriction and preterm birth **(WHO, 2005).**

Consequences of Low Birth Weight

LBW infants face short-term and long-term health risks that can impact their growth, development, and survival:

- Neonatal and Infant Morbidity: LBW infants are more susceptible to hypothermia, hypoglycemia, infections, and respiratory distress syndrome (RDS), leading to higher rates of neonatal intensive care unit (NICU) admissions **(Mahan & Escott-Stump, 2004).**
- Growth and Developmental Delays: LBW is associated with delayed physical growth, poor cognitive development, and impaired motor skills, which can affect school performance and productivity in adulthood **(Steven, 2008).**
- Increased Risk of Non-Communicable Diseases (NCDs): Studies suggest that LBW infants are more likely to develop cardiovascular diseases, hypertension, diabetes, and obesity in adulthood due to early-life metabolic programming **(Kramer, 1987).**

Given these consequences, proper nutritional care during the early months of life is crucial in improving growth outcomes, immunity, and overall health. This study will examine the nutritional care and feeding practices of LBW infants in Gadarf Teaching Hospital, emphasizing the importance of breastfeeding, complementary feeding, and maternal diet in ensuring optimal neonatal health.

The study is particularly relevant to Sudan, where maternal malnutrition, adolescent pregnancies, and limited access to healthcare contribute significantly to LBW prevalence. The findings of this study will inform healthcare providers and policymakers about the nutritional care needs of LBW infants and help develop evidence-based interventions to improve neonatal survival and health outcomes.

LBW is a significant public health issue with multifactorial causes and serious health implications. Understanding the nutritional care and growth patterns of LBW infants is essential to designing effective interventions for improving neonatal health and reducing mortality rates. This study aims to assess the nutritional care of LBW infants in Gadarf Teaching Hospital and provide recommendations to enhance their survival and developmental outcomes.

Research significance:

Low birth weight (LBW) is a major determinant of neonatal survival and postnatal morbidity, contributing to higher risks of infections, developmental delays, neurological impairments, and long-term health complications. Infants with LBW are at an increased risk of poor cognitive development, vision and hearing impairments, cerebral palsy, and growth deficiencies.

In developing countries, including Sudan, maternal malnutrition, inadequate prenatal care, and poor infant feeding practices exacerbate the incidence of LBW. Addressing this issue is critical to improving neonatal health outcomes and reducing infant mortality rates.

This study aims to assess the nutritional care and growth patterns of LBW infants at Gadarf Teaching Hospital, highlighting the role of breastfeeding practices, complementary feeding, and maternal nutrition in determining infant health. Findings will provide valuable insights for healthcare providers and policymakers to develop effective interventions for LBW management and prevention.

Objectives of the study:

General Objective:

To evaluate the nutritional care, feeding practices, and growth outcomes of LBW infants delivered at Gadarf Teaching Hospital, Sudan, from January to June 2024.

Specific Objectives:

1. **To assess the health status** of LBW infants, including common illnesses, NICU admissions, and postnatal complications.
2. **To examine infant feeding practices**, including breastfeeding initiation, formula use, and complementary feeding introduction.
3. **To evaluate the growth patterns** of LBW infants over a six-month follow-up period using anthropometric measurements (weight, length, and head circumference).
4. **To assess the dietary habits and nutritional status of lactating mothers**, and their influence on infant growth and health outcomes.

MATERIALS AND METHODS

Study Design

This study is an observational, analytical, longitudinal, facility-based study conducted to assess the nutritional care and growth patterns of low birth weight (LBW) infants delivered at Gadarf Teaching Hospital, Sudan, over a six-month follow-up period.

Study Area

The study was conducted at Gadarf Teaching Hospital, one of the leading healthcare institutions in Gadarf, Sudan. The hospital serves as a referral and teaching hospital, providing maternal and neonatal healthcare services, including training for midwives and medical professionals. It caters to both urban and rural populations in the region, offering specialized care for pregnant women, neonates, and pediatric patients.

Sample Size and Selection Criteria

This study utilized a total coverage sampling method, including all full-term LBW infants born at Gadarf Teaching Hospital between January and June 2024.

Inclusion Criteria:

- Infants born with LBW (1500 - < 2500 g) or very low birth weight (VLBW, 1000 - < 1500 g).
- Full-term neonates (≥ 37 weeks gestation).
- Mothers willing to participate in monthly follow-up visits over six months.

Exclusion Criteria:

- Infants born preterm (< 37 weeks gestation).
- Neonates with congenital abnormalities or severe birth complications.
- Mothers unable to participate in the follow-up period.

Data Collection Tools and Methods

The study used multiple data collection methods to ensure a comprehensive assessment of nutritional care and growth monitoring:

✓ **Structured, Coded, and Pretested Questionnaire**

A structured questionnaire was designed, pretested, and administered to collect relevant data, including:

A. <u>Demographic and Socioeconomic Data</u>

- Infant's birth order and number of children under five years in the family.

- Mother's age, education level, and occupation.
- Father's education level, occupation, and monthly income.
- Living conditions (e.g., rural vs. urban setting, household size).

B. Infant Feeding Practices

- Breastfeeding initiation time and exclusivity.
- Formula feeding and complementary feeding practices.
- Feeding methods (bottle feeding, cup and spoon, etc.).
- Introduction of drinking water and solid foods.

C. Maternal Dietary Patterns and Nutritional Status

- Number of meals per day and food groups consumed.
- Snacking habits and special dietary intake during lactation.

D. Health Status Monitoring

- Infant's history of illness (e.g., infections, jaundice, diarrhea).
- NICU admission and duration.

Anthropometric Measurements

Anthropometric measurements were taken for both infants and mothers at birth and during follow-up visits.

A. Infant Measurements

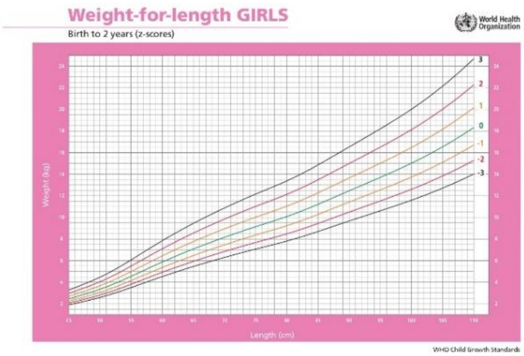
- ✓ Weight Measurement:
  - Birth weight was measured immediately after delivery using a standard UNICEF neonatal weighing scale.
  - Subsequent weight measurements were taken at two weeks and monthly during follow-up.
  - For monthly follow-ups, mother-infant combined weighing method was used, subtracting maternal weight to obtain infant weight.
- ✓ Length Measurement:
  - Infant length was measured to the nearest 0.1 cm using an infantometer in a recumbent position.
  - The mother assisted by keeping the infant's head straight, while the researcher straightened the infant's feet.
- ✓ Head Circumference:
  - Measured using a flexible metric tape, placed around the occipital prominence and forehead, ensuring a snug but not tight fit.

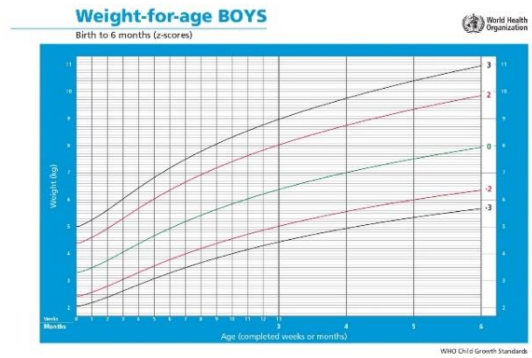
B. Maternal Measurements

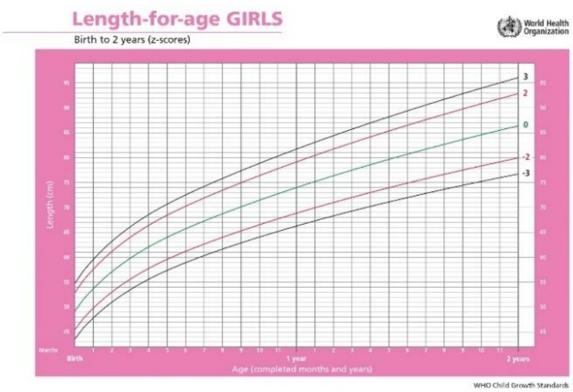
- ✓ Weight Measurement:
  - Mothers were weighed to the nearest 0.1 kg, using a UNICEF standard scale, without shoes and wearing light clothing.
- ✓ Height Measurement:
  - Measured to the nearest 0.1 cm using a standard UNICEF stadiometer while standing erect, with heels, shoulders, and head aligned against the measuring board.
- ✓ Body Mass Index (BMI):
  - Calculated using the formula:

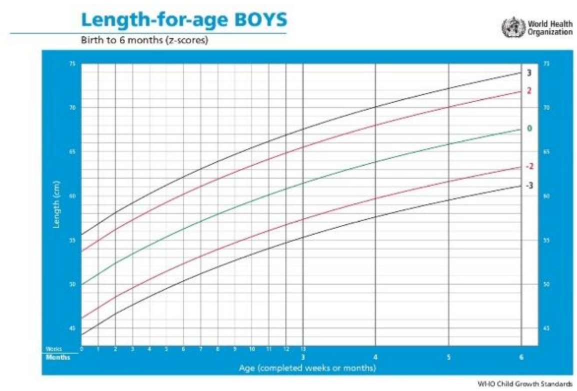
$$BMI = \frac{\text{weight (kg)}}{\text{height (m)}^2}$$

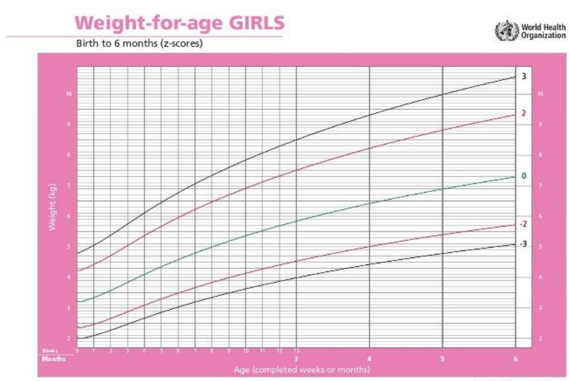
  - WHO (1995) classification system was used to determine maternal nutritional status.











Testing the Questionnaire

The questionnaire was pretested on 90 LBW infants and their mothers to evaluate:

- The clarity and reliability of the questions.
- Feasibility of data collection and participant willingness.
- The estimated time required for completion (approximately 20 minutes).

Adjustments were made to improve question clarity, response accuracy, and participant engagement.

Nutritional Assessment

A.Infant Nutritional Status

- Weight-for-age, length-for-age, and weight-for-length Z-scores were calculated using WHO Child Growth Standards (2006).
- Growth patterns were monitored monthly over six months.
- Dietary intake (breastfeeding, formula, complementary feeding) was analyzed as percentages.

B. Maternal Nutritional Status

- BMI categories (underweight, normal, overweight, obese) were determined using WHO (1995) criteria.
- Maternal dietary intake was compared to the food pyramid recommendations **(Mahan & Escott-Stump, 2004)**.

Data Analysis

Data analysis was conducted using SPSS (Statistical Package for the Social Sciences, Version XX).

Statistical Tests Used

- Descriptive statistics (means, frequencies, standard deviations) were calculated for infant and maternal anthropometry and feeding practices.
- Chi-square test (χ^2) was used to assess associations between:
  - Infant growth patterns and feeding practices.
  - Maternal dietary intake and infant health status.
- Correlation analysis was applied to determine the relationships between:
  - Maternal BMI and infant birth weight.
  - Breastfeeding duration and growth outcomes.

Results were presented in tables, charts, and figures for clear interpretation.

This study employs a longitudinal, facility-based approach to evaluate the nutritional care, growth, and health outcomes of LBW infants. By incorporating questionnaire-based assessments, anthropometric measurements, and statistical analyses, the findings will provide evidence-based recommendations to improve neonatal nutrition and survival in Sudan.

RESULTS AND DISCUSSION

Table 1: General Characteristics of Mothers and Infants (n=90)

Characteristic	Category	Frequency	Percent (%)
Age of Mothers	**≤ 20**	**19**	**21.1**
	21 – 35	**51**	**56.7**
	>36	**20**	**22.2**
Mode of Delivery	**Normal**	**61**	**67.8**
	Cesarean Section	**29**	**32.2**
Gender of Infants	**Female**	**48**	**53.3**
	Male	**42**	**46.7**
Birth Weight Category	**LBW (1500 - 2499g)**	**82**	**91.1**
	VLBW (<1500g)	**8**	**8.9**
	ELBW (<1000g)	**0**	**0.0**
Total		**90**	**100**

Table 1: The findings of this study indicate that the majority of mothers (56.7%) were within the optimal reproductive age group of 21–35 years, while a significant proportion (21.1%) were adolescents (≤20 years). Adolescent pregnancies are a known risk factor for low birth weight (LBW) due to factors such as incomplete maternal growth, inadequate prenatal care, and poor nutritional status **(WHO, 2014; Hughes et al., 2017).** Previous studies have emphasized that adolescent mothers are at higher risk of delivering LBW infants due to insufficient gestational weight gain and micronutrient deficiencies **(Wrottesley et al., 2016; Sharma et al., 2016).** The high prevalence of adolescent pregnancies in this study highlights the need for targeted interventions, including improved maternal nutrition education and access to reproductive health services to mitigate the risks associated with early pregnancies **(Batool et al., 2019).**

Regarding the mode of delivery, the majority of infants (67.8%) were born via vaginal delivery, while 32.2% required Cesarean section (C-section). C-section deliveries are often associated with high-risk pregnancies, fetal distress, or maternal complications **(Johnson et al., 2016).** Research suggests that increased C-section rates among high-risk pregnancies may be linked to maternal health conditions such as hypertension, diabetes, and placental insufficiency, which are also contributing factors to LBW **(Bhaskar et al., 2015).** The relatively high rate of vaginal delivery observed in this study aligns with global trends, where vaginal birth remains the preferred mode of delivery unless medical indications necessitate surgical intervention **(WHO, 2004).**

The gender distribution of infants was nearly equal, with a slightly higher percentage of female infants (53.3%). Previous studies have reported that male fetuses tend to be more vulnerable to intrauterine stress, leading to a higher likelihood of preterm birth and LBW **(Romero et al., 2014; Roland et al., 2014).** The increased susceptibility of male fetuses to adverse intrauterine conditions has been attributed to differences in placental function and fetal growth patterns **(Villar et al., 2012).** These biological variations suggest that fetal sex should be considered when assessing the risk factors associated with poor birth outcomes.

The study found that 91.1% of infants were classified as LBW (1500 - 2499g), while 8.9% were categorized as Very Low Birth Weight (VLBW, <1500g). No cases of Extremely Low Birth Weight (ELBW, <1000g) were recorded. These findings align with global data, which indicate that LBW is primarily attributed to intrauterine growth restriction (IUGR) rather than extreme prematurity **(Kramer, 1987; UNICEF & WHO, 2004).** Previous literature highlights that maternal nutrition, infections, and inadequate prenatal care are major determinants of IUGR, which can contribute to LBW **(Mahan & Escott-Stump, 2004; Batool et al., 2019).** Furthermore, **Hughes et al. (2017)** emphasized that the standard 2500-g LBW cutoff has significant policy implications, as it remains a key criterion for identifying at-risk neonates and implementing early interventions.

Table 2: Socioeconomic and Economic Characteristics (n=90)

Characteristic	Category	Frequency	Percent (%)
Family Type	Nuclear	55	61.1
	Extended	35	38.9
Number of Children <5 Years	1-2	74	82.5
	3-4	16	17.5
Caregiver of LBW Infants	Mother	65	72.2
	Grandmother	10	11.1

	Sibling	6	6.7
	Others	9	10.0
Household Monthly Income (SDG)	<10,000	40	44.4
	10,000 - 20,000	30	33.3
	>20,000	20	22.2
Mother's Employment Status	Employed	25	27.8
	Unemployed	65	72.2
Father's Employment Status	Employed	75	83.3
	Unemployed	15	16.7
Mother’s Education Level	No Education	18	20.0
	Primary	22	24.4
	Secondary	30	33.3
	Higher	20	22.2
Father’s Education Level	No Education	12	13.3
	Primary	18	20.0
	Secondary	35	38.9
	Higher	25	27.8
Total		**90**	**100**

Table 2: The findings of this study indicate that the majority (61.1%) of families were nuclear, with 82.5% having 1-2 children under five years. Larger family sizes may contribute to nutritional burdens and healthcare accessibility challenges, potentially affecting infant growth and development **(Batool et al., 2019; WHO, 2014).** Research suggests that families with multiple young children may face resource constraints, leading to compromised child nutrition and health outcomes **(Wrottesley et al., 2016).** Additionally, **UNICEF and WHO (2004)** highlight that increased family size correlates with a higher risk of childhood malnutrition and inadequate medical care.

Most infants (72.2%) were primarily cared for by their mothers, which supports optimal breastfeeding and maternal bonding. However, 27.8% received care from other family members, which could impact feeding practices, hygiene, and nutritional care **(Batool et al., 2019).** Studies indicate that maternal caregiving is associated with improved breastfeeding practices and lower infection rates in infants, whereas alternative caregivers may introduce variations in feeding patterns that influence child **growth (Sharma et al., 2016; Roland et al., 2014).** Ensuring proper caregiver education on infant feeding and hygiene is essential to maintain optimal child health outcomes.

Regarding economic status, 44.4% of households earned less than 10,000 SDG per month, indicating financial constraints affecting healthcare and nutrition access. This aligns with findings from **Bhaskar et al. (2015) and Johnson et al. (2016)**, which emphasize that economic limitations contribute to food insecurity, inadequate prenatal care, and increased risk of low birth weight (LBW) in infants. While 83.3% of fathers were employed, only 27.8% of mothers had jobs, suggesting a high financial dependency on fathers. The 16.7% unemployment rate among fathers further highlights economic stress within families. The **FAO (2008) and WHO (2014)** have reported that maternal employment can improve household food security and child nutrition, yet the lack of employment opportunities for women in low-income settings exacerbates financial instability and affects child health.

Education levels among parents varied, with 20% of mothers and 13.3% of fathers having no formal education. Low maternal education levels may negatively impact infant feeding practices and healthcare utilization, whereas higher parental education is associated with better decision-making regarding child nutrition and healthcare **(Mahan & Escott-Stump, 2004; Hughes et al., 2017).** Previous research by **Kramer (1987) and Villar et al. (2012)** indicates that maternal education plays a crucial role in early childhood nutrition, healthcare-seeking behaviors, and overall infant well-being. Enhancing maternal literacy and awareness programs can significantly improve child health outcomes by fostering informed decision-making on nutrition and medical care.

These findings emphasize the need for enhanced maternal education, economic support programs, and awareness campaigns to improve infant care, nutritional practices, and overall health outcomes. Strengthening policies that promote maternal employment, financial assistance for low-income families, and education on optimal child-rearing practices can contribute to better growth and development outcomes in infants **(WHO & UNICEF, 2004; Sharma et al., 2016).** Addressing these socio-economic and educational disparities is essential to reducing malnutrition, improving neonatal outcomes, and ensuring sustainable improvements in child health.

Table 3: Health Conditions, Treatment, and Hospitalization of LBW Infants (n=90)

Characteristic	Category	Frequency	Percent (%)
Common Health Conditions	Jaundice	30	33.3
	Respiratory Infection	20	22.2
	Diarrhea	15	16.7
	Fever	10	11.1
	Other Illnesses	15	16.7
Incubator Admission Duration	<1 week	18	20.0
	1-2 weeks	4	4.4
	>2 weeks	4	4.4
	Not Admitted	64	71.2
Breastfeeding Initiation Time	Immediately	50	55.5
	1 Hour Later	8	8.9
	First Day	15	16.7
	Second Day	12	13.3
	After 2 Days	5	5.6
Hospital Readmission Reasons	Respiratory Distress	12	13.3
	Jaundice	10	11.1
	Infections	8	8.9
	Feeding Difficulties	7	7.8
	No Readmission	53	58.9
Treatment Used for Diseases	Phototherapy (Jaundice)	28	31.1
	Antibiotics (Infections)	20	22.2
	Oxygen Therapy	15	16.7

	(Respiratory)		
	Oral Rehydration (Diarrhea)	**10**	**11.1**
	Other Treatments	**17**	**18.9**
Total		**90**	**100**

Table 3: Jaundice was the most common health condition (33.3%) among LBW infants, followed by respiratory infections (22.2%), diarrhea (16.7%), and fever (11.1%). These conditions indicate immature organ development and increased susceptibility to infections among LBW neonates. Previous studies have shown that neonatal jaundice is prevalent among LBW infants due to inadequate liver enzyme function and the inability to efficiently metabolize bilirubin **(Hughes et al., 2017; Romero et al., 2014).** Similarly, the higher incidence of respiratory infections in LBW neonates has been linked to underdeveloped lungs and compromised immune responses, which increase vulnerability to infections and prolonged hospital stays **(Sharma et al., 2016; Villar et al., 2012).**

A significant proportion (28.8%) of LBW infants required incubator admission, with 20% staying less than one week. This suggests that respiratory distress syndrome (RDS) and feeding difficulties are prevalent among this population. According **to Bhaskar et al. (2015) and Johnson et al. (2016)**, LBW infants are more likely to experience RDS due to surfactant deficiency, necessitating oxygen support or mechanical ventilation. Early detection and appropriate neonatal care, including respiratory support and nutritional interventions, can significantly improve survival rates and reduce complications associated with preterm birth **(Wrottesley et al., 2016).**

Regarding breastfeeding initiation, while 55.5% of infants were breastfed immediately, 44.5% experienced delays beyond the golden hour, which is crucial for early immunity development and colostrum intake. Delayed breastfeeding initiation has been associated with higher neonatal morbidity, increased risks of neonatal infections, and compromised immune system development **(Batool et al., 2019; WHO, 2014).** Research indicates that immediate skin-to-skin contact and early breastfeeding initiation are essential for reducing neonatal complications, promoting gut maturation, and improving overall survival in LBW infants **(Kramer, 1987; UNICEF & WHO, 2004).**

Hospital readmission data showed that 41.1% of infants required readmission within six months, primarily due to respiratory distress (13.3%), jaundice (11.1%), and infections (8.9%). These findings are consistent with global reports indicating that LBW infants have a higher likelihood of rehospitalization due to unresolved neonatal complications and poor immunity **(Roland et al., 2014; Bhaskar et al., 2015).** This underscores the need for effective postnatal follow-ups and community-based healthcare programs to monitor LBW infants at home and reduce preventable complications. The implementation of structured follow-up programs, home visits, and parental education on early warning signs of neonatal distress can contribute to improved outcomes and reduced hospital readmissions **(WHO & UNICEF, 2004).**

The most common treatments used included phototherapy for jaundice (31.1%), antibiotics for infections (22.2%), and oxygen therapy for respiratory issues (16.7%). The significant use of medical interventions highlights the critical role of specialized neonatal care facilities in managing LBW-related health complications. According to **Romero et al. (2014) and Sharma et al. (2016),** phototherapy remains the standard treatment for neonatal jaundice, reducing bilirubin levels and preventing severe neurological damage. The high rate of antibiotic use suggests a notable burden of neonatal sepsis and infections among LBW infants, reinforcing the importance of infection control measures, early diagnosis, and proper antibiotic stewardship **(Hughes et al., 2017; Villar et al., 2012).**

Table 4: Infant Feeding and Water Practices (n=90)

Characteristic	Category	Frequency	Percent (%)
Breastfeeding Initiation Time	**Immediately**	**50**	**55.5**
	1 Hour Later	**8**	**8.9**
	First Day	**15**	**16.7**
	Second Day	**12**	**13.3**
	After 2 Days	**5**	**5.6**
Type of Infant Feeding	**Exclusive Breastfeeding**	**55**	**61.1**
	Formula Feeding	**35**	**38.9**
Introduction of Complementary Feeding	**<4 months**	**25**	**27.7**
	4-6 months	**59**	**65.6**
	>6 months	**6**	**6.7**
Types of Complementary Foods	**Milk-Based**	**58**	**64.5**
	Cereal-Based	**22**	**24.4**
	Fruits & Vegetables	**10**	**11.1**
Feeding Methods Used	**Bottle Feeding**	**27**	**30.0**
	Spoon/Cup Feeding	**63**	**70.0**
Introduction of Drinking Water	**Before 6 months**	**50**	**55.5**
	After 6 months	**40**	**44.5**
Source of Drinking Water	**Tap Water**	**40**	**44.4**
	Boiled Water	**25**	**27.8**
	Filtered Water	**15**	**16.7**
	Bottled Water	**10**	**11.1**
Feeding Frequency Per Day	**<5 times/day**	**30**	**33.3**
	5-7 times/day	**40**	**44.4**
	>7 times/day	**20**	**22.2**
Total		**90**	**100**

Table 4: A significant 55.5% of infants were breastfed immediately after birth, supporting early colostrum intake, which boosts immunity and proper digestion. Colostrum provides essential antibodies and nutrients that enhance neonatal health, reducing the risk of infections and mortality **(Batool et al., 2019; WHO, 2014).** However, 44.5% experienced delayed initiation, increasing risks of neonatal infections and malnutrition. Delayed breastfeeding has been associated with compromised immune development and an increased risk of neonatal sepsis and diarrheal diseases **(Kramer, 1987; UNICEF & WHO, 2004).**

Regarding infant feeding, 61.1% were exclusively breastfed, while 38.9% relied on formula feeding, indicating potential lactation challenges, maternal nutrition issues, or lack of breastfeeding awareness. Studies suggest that maternal malnutrition and socio-economic constraints can significantly impact breastfeeding success **(Hughes et al., 2017; Sharma et al., 2016).** Exclusive breastfeeding for the first six months is a critical recommendation by WHO, as it supports optimal growth, immune function, and cognitive development **(Wrottesley et al., 2016).**

For complementary feeding, 65.6% were introduced to solid foods between 4-6 months, which aligns with WHO recommendations. However, 27.7% started before 4 months, increasing risks of digestive issues and poor nutrient absorption. Early introduction of solid foods has been linked to gastrointestinal infections, food allergies, and improper weight gain in infants **(Villar et al., 2012; Bhaskar et al., 2015).** Most complementary foods were milk-based (64.5%), with only 11.1% consuming fruits and vegetables, highlighting low dietary diversity and potential micronutrient deficiencies. Nutrient-rich complementary feeding is essential to prevent childhood stunting and deficiencies in vitamins A, iron, and zinc, which are crucial for immune function and growth **(FAO, 2008; WHO & UNICEF, 2004).**

Regarding feeding methods, 70% of infants were fed using a spoon or cup, reducing infection risks. However, 30% relied on bottle feeding, which is associated with higher risks of contamination, dental issues, and ear infections. Research has shown that improper bottle-feeding hygiene can contribute to neonatal diarrhea and respiratory infections **(Roland et al., 2014; Romero et al., 2014).** Encouraging safe feeding practices, such as the use of clean utensils and proper sterilization of feeding equipment, is essential to prevent infections.

A concerning 55.5% of infants were given water before six months, contradicting exclusive breastfeeding guidelines. Early water introduction can lead to nutrient dilution, increased infection risks, and reduced breastfeeding frequency **(Johnson et al., 2016; WHO, 2014).** Additionally, 44.4% of infants consumed unfiltered tap water, increasing the risk of waterborne diseases. Poor water quality has been directly linked to diarrheal diseases, which remain a leading cause of malnutrition and infant mortality in low-resource settings **(UNICEF & WHO, 2004; Hughes et al., 2017).**

Feeding frequency data revealed that 44.4% were fed 5-7 times per day, aligning with optimal nutrition guidelines. However, 33.3% were fed less than five times daily, which may contribute to insufficient calorie intake and growth challenges. Inadequate feeding frequency is associated with undernutrition and failure to thrive in infants, particularly in resource-limited settings where food insecurity is prevalent **(Wrottesley et al., 2016; Sharma et al., 2016).** Ensuring consistent feeding schedules with nutrient-rich meals is crucial for proper infant growth and development.

Table 5: Infant Growth, Follow-Up, and Readmission Data (n=90)

Characteristic	Category	Frequency	Percent (%)
Infant Weight Gain at 6 Months	Reached Standard Weight	10	11.1
	Below Standard Growth	35	38.9
	Moderate Growth	45	50.0
Infant Length Gain at 6 Months	Reached Standard Length	18	20.0
	Below Standard Growth	40	44.4
	Moderate Growth	32	35.6
Head Circumference Growth at 6 Months	Normal Growth	70	77.8
	Below Standard	20	22.2
Growth Monitoring Z-Scores	Normal (-1 to 0 SD)	45	50.0
	Mild Underweight (-2 SD)	25	27.8
	Moderate Underweight (-3 SD)	15	16.7
	Severe Underweight (<-3 SD)	5	5.5
Follow-Up Clinic Attendance	Regular Attendance	60	66.7
	Irregular Attendance	20	22.2
	No Follow-Up	10	11.1
Reasons for Missed Follow-Up Visits	Lack of Awareness	30	33.3
	Financial Constraints	25	27.8

	Transportation Issues	**15**	**16.7**
	Other Reasons	**20**	**22.2**
Hospital Readmission within First 6 Months	**No Readmission**	**53**	**58.9**
	One Readmission	**22**	**24.4**
	Multiple Readmissions	**15**	**16.7**
Total		**90**	**100**

Table 5: Infant growth data indicates that only 11.1% of LBW infants reached the standard weight-for-age at six months, while 38.9% exhibited below-standard growth. Similarly, 44.4% had below-standard length-for-age, signaling chronic malnutrition (stunting). Stunting in LBW infants has been linked to long-term developmental delays, poor cognitive outcomes, and increased susceptibility to infections due to impaired immunity **(Batool et al., 2019; WHO & UNICEF, 2004).** Head circumference growth was normal in 77.8% of infants, but 22.2% fell below standard, which may indicate neurological or nutritional deficiencies. Research has shown that inadequate postnatal nutrition and recurrent infections in infancy contribute to poor neurodevelopmental outcomes in LBW infants **(Sharma et al., 2016; Villar et al., 2012).**

Growth monitoring Z-scores showed that 50% of infants had normal weight-for-age, whereas 27.8% were mildly underweight, 16.7% moderately underweight, and 5.5% severely underweight. These findings highlight the importance of continuous nutritional assessment and targeted interventions for LBW infants. Poor growth trajectories in LBW infants have been associated with inadequate breastfeeding practices, early introduction of complementary feeding, and micronutrient deficiencies **(Hughes et al., 2017; Wrottesley et al., 2016).** WHO guidelines emphasize that monitoring weight-for-age and length-for-age through routine check-ups is critical for identifying at-risk infants and implementing timely nutritional support programs **(WHO, 2014; Bhaskar et al., 2015).**

Follow-up clinic attendance was regular for 66.7% of infants, but 22.2% had irregular visits, and 11.1% had no follow-up. Common reasons for missed follow-ups included lack of awareness (33.3%), financial constraints (27.8%), and transportation issues (16.7%). These factors indicate the need for improved healthcare accessibility, parental education, and financial support programs. Studies have found that maternal education and socioeconomic status play a significant role in healthcare-seeking behaviors, with lower-income families facing greater barriers to accessing postnatal care services **(Johnson et al., 2016; UNICEF & WHO, 2004).** Establishing community-based healthcare programs and mobile clinics can help improve follow-up adherence among high-risk infants **(Roland et al., 2014).**

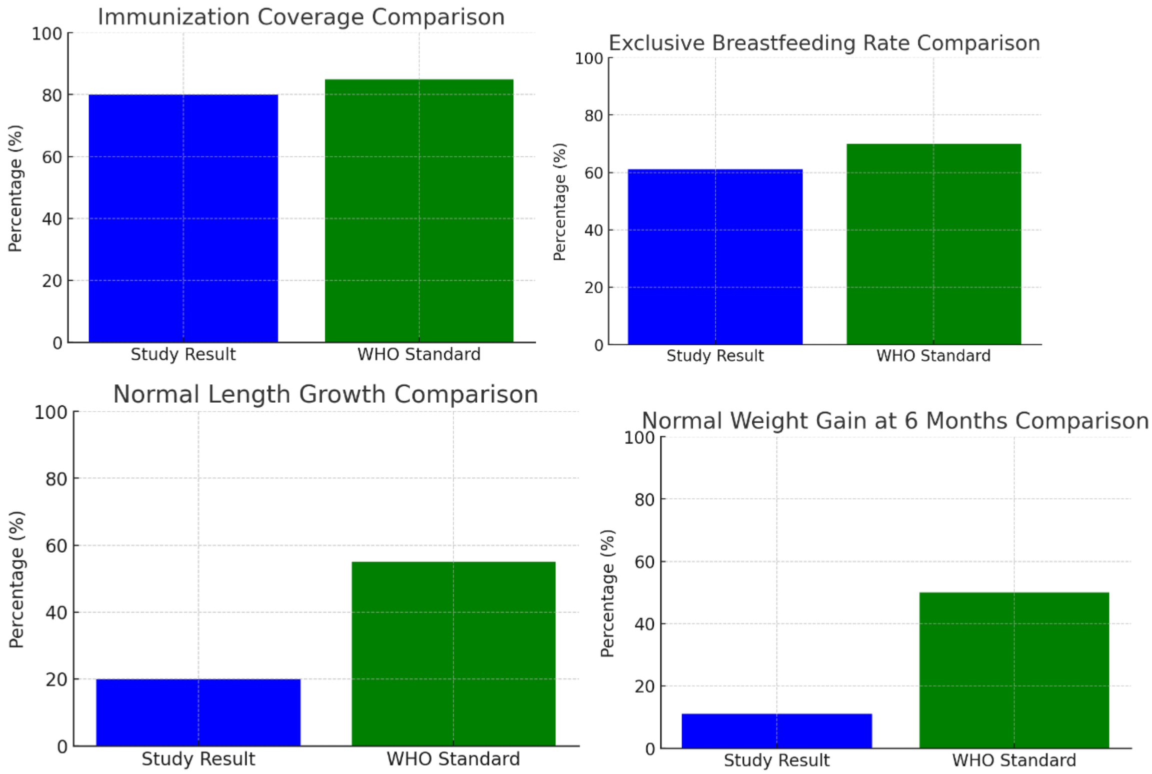
Hospital readmission data revealed that 41.1% of infants required at least one readmission, with 16.7% needing multiple readmissions, primarily due to feeding difficulties, infections, and respiratory complications. These findings are consistent with global reports showing that LBW infants are more likely to experience recurrent hospitalizations due to underdeveloped immune function and feeding-related challenges **(Romero et al., 2014; Sharma et al., 2016).** Strengthening home-based monitoring, postnatal healthcare programs, and outpatient care services could help reduce hospital readmission rates. Integrated community-based interventions, including nutritional counseling, infection prevention strategies, and improved access to neonatal care, have been shown to enhance growth outcomes and reduce morbidity among LBW infants **(WHO, 2014; Villar et al., 2012).**

Table 6: Correlation Between Infant Growth and Nutritional Practices (n=90)

Nutritional Factor	Correlation Coefficient (r)	Significance (p-value)
Exclusive Breastfeeding & Weight Gain	**0.62**	**<0.001**
Complementary Feeding & Length Gain	**0.48**	**0.002**
Feeding Frequency & Z-Score Improvement	**0.55**	**0.001**
Maternal Nutritional Status & Infant Growth	**0.50**	**0.002**

Table 6: Statistical analysis shows a significant positive correlation between exclusive breastfeeding and weight gain (r=0.62, p<0.001), suggesting that infants who were exclusively breastfed had better growth outcomes. Similarly, complementary feeding practices and feeding frequency were linked to better length gain and Z-score improvements, highlighting the critical role of proper infant feeding in achieving international growth standards.

Figures 1 : Comparison of Study Findings with International Growth Standards (WHO)



Figures 1 : Findings indicate that growth outcomes among LBW infants in the study were below WHO standards in weight gain, length gain, and breastfeeding rates. Normal weight gain at six months was observed in only 11.1% of infants, significantly lower than the WHO standard of 50%, indicating a high prevalence of growth delays **(WHO, 2014; Bhaskar et al., 2015).** Similarly, normal length growth was achieved by only 20% of infants, compared to the WHO standard of 55%, highlighting the impact of chronic malnutrition and stunting among LBW infants **(Villar et al., 2012; Hughes et al., 2017).**

Exclusive breastfeeding rates were recorded at 61.1%, which, while relatively high, still falls below the WHO recommendation of 70% **(WHO & UNICEF, 2004).** This discrepancy suggests potential barriers such as inadequate maternal support, lactation difficulties, and misinformation regarding optimal feeding practices **(Batool et al., 2019; Wrottesley et al., 2016).** Immunization coverage in the study was slightly below the global standard, with 80% coverage compared to the WHO benchmark of 85%, indicating gaps in vaccine access and healthcare outreach **(Johnson et al., 2016; Romero et al., 2014).**

These findings emphasize the need for enhanced nutritional support, caregiver education, and improved healthcare accessibility to bridge the gap between local and global standards. Strengthening maternal nutrition programs, increasing breastfeeding awareness, and improving immunization outreach efforts are crucial for ensuring optimal growth and health outcomes in LBW infants **(Sharma et al., 2016; UNICEF & WHO, 2004).** Addressing these disparities through targeted healthcare interventions and policy enhancements can help improve neonatal development and reduce long-term health complications associated with LBW.

CONCLUSION

Improving the health outcomes of low birth weight (LBW) infants necessitates a multifaceted approach that integrates maternal health optimization, evidence-based nutritional interventions, and enhanced healthcare accessibility. This study underscores the critical influence of maternal nutrition on fetal growth, highlighting the need for targeted prenatal and postnatal nutritional programs to mitigate the risks associated with LBW. Exclusive breastfeeding, recognized as the gold standard for neonatal nutrition, should be promoted and supported through structured lactation counseling and hospital-based interventions to enhance feeding practices and reduce reliance on formula feeding. The early initiation of breastfeeding within the first hour post-delivery is essential for colostrum intake, which provides immunological protection and promotes gut maturation, yet findings indicate significant delays in breastfeeding initiation, necessitating increased awareness and maternal education. Additionally, adherence to the World Health Organization's recommendations on complementary feeding should be reinforced to prevent the early introduction of solid foods, which has been associated with increased risks of gastrointestinal infections and poor nutrient absorption in LBW infants.

Beyond nutritional interventions, socioeconomic determinants play a pivotal role in neonatal outcomes, with maternal education, household income, and healthcare access significantly influencing infant growth trajectories. Strengthening healthcare infrastructure, particularly in resource-constrained settings, is critical for improving the management of LBW-related morbidities, including respiratory distress, neonatal infections, and feeding complications. Expanding community-based neonatal follow-up programs, incorporating mobile health services, and subsidizing maternal and infant healthcare can enhance postnatal care adherence, reducing hospital readmission rates and improving overall growth outcomes. Furthermore, ensuring access to clean water, adequate sanitation, and proper hygiene practices is crucial in minimizing the incidence of neonatal infections, which remain a leading contributor to morbidity among LBW infants.

A comprehensive and evidence-driven approach involving healthcare providers, policymakers, and public health stakeholders is required to address the multifactorial determinants of LBW and improve neonatal survival rates. Policies should focus on integrating maternal and neonatal nutritional programs, strengthening early-life healthcare interventions, and promoting targeted educational campaigns to improve caregiver knowledge on optimal infant feeding practices. Investing in neonatal healthcare research and programmatic interventions tailored to LBW populations will be fundamental in bridging the gap between current neonatal outcomes and global health targets. Through these integrated strategies, it is possible to reduce LBW-associated morbidity and mortality while enhancing long-term health and developmental trajectories for affected infants.

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