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Evaluating Uniformity in Clinical Profile of Preterm Low-Birth-Weight Neonates: A Chi-Square Analysis of a 122-Infant Cohort

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Abstract: Infants who are born before 37 weeks of gestation and have birth weight less than 2.5 Kg are termed as Preterm Low-Birth Weight Neonates. It is vital to analyze the distribution of characteristics of Preterm Low-Birth Weight Neonates such as age at admission, sex, birth weight, gestational duration and nutritional approaches for meeting their needs of specialized care. The study aims to explore uniformity in Clinical Profile of these neonates. A cross-sectional study investigation was carried out among 122 neonates at a tertiary level NICU from July 2024 to December 2024 using consecutive sampling technique. Data was gathered on age, sex, birth weight, gestational age, and feeding practices using Case Record Form. The chi-square test was used to analyze the findings. It revealed thattheir birth weights point outneed for advanced NICU resources, and their diverse traits make them an ideal group for learning more about preterm care.

Keywords: Chi-square analysis, Clinical distribution, Low birth weight, Neonatal traits, NICU, Preterm infants.

I. Introduction

Infants born before 37 weeks of gestation and weighing less than 2.5 kg, known as preterm low-birth-weight neonates, represent a critical group requiring advanced care in neonatal intensive care units (NICUs) [1]. Their underdeveloped organ systems lead to significant health risks, including respiratory failure due to immature lungs, cardiovascular instability from weak autonomic control, nutritional challenges from limited fat reserves, and frequent infections due to an incomplete immune response [2]. These issues result in elevated rates of complications, such as chronic lung disease, cerebral hemorrhage, and developmental delays, particularly in regions with limited healthcare access [3].

Globally, preterm births account for approximately 10% of all deliveries, with low-birth-weight infants comprising a substantial subset, contributing to over 1 million neonatal deaths annually [4]. In specialized NICUs, these infants benefit from interventions like mechanical ventilation, tailored feeding regimens, and strict infection prevention, all aimed at improving survival and long-term health. Detailed profiling of their clinical and demographic characteristics is essential for customizing these interventions, allocating resources effectively, and shaping research to enhance outcomes.

The characteristics of interest—age at NICU admission, sex, birth weight, gestational age, and feeding methods—offer valuable insights into the care needs of preterm infants. Birth weight and gestational age are primary indicators of health risks, with infants below 1.5 kg or 32 weeks facing heightened vulnerability to hypothermia, low blood sugar, and infections [1]. Sex differences influence preterm birth prevalence, with males often at higher risk due to slower developmental milestones, particularly in lung and brain maturation [5]. Nutritional strategies, whether through breast milk, formula, or a combination, are crucial for growth and immunity, as preterm infants frequently struggle with feeding due to weak sucking abilities [6].

Examining the distribution of these traits is a cornerstone of neonatal care and research. A skewed distribution, such as a concentration of infants in a specific weight range, may point to biological trends, clinical practices, or healthcare system dynamics, such as selective referrals to advanced facilities. An even distribution suggests a varied cohort, suitable for applying findings across preterm populations. The chi-square goodness-of-fit test is an effective statistical tool for determining whether observed distributions differ from an expected equal spread, offering a clear method to analyze categorical data [7].

This study examines a cohort of 122 preterm low-birth-weight neonates in a tertiary NICU, using chi-square tests to assess the uniformity of their clinical characteristics.

This analysis establishes a quantitative basis for understanding the cohort's profile, informing NICU operations, and paving the way for future studies on preterm infant care.

II. Materials and Methods

A. Study Design and Setting

This cross-sectional study was conducted in the NICU of selected hospital of Delhi, a tertiary hospital in India, equipped with cutting-edge technology, including non-invasive ventilators, real-time monitoring systems, and a skilled team of neonatal specialists. The study was conducted from July 2024 to December 2024, among preterm low-birth-weight infants admitted during standard clinical operations. The NICU's capacity to handle complex cases, such as those requiring phototherapy or parenteral nutrition, made it an ideal setting for this research.

The study received ethical clearance from the Institutional Review Board, adhering to global ethical standards. Guardians provided written informed consent after receiving comprehensive information about the study's objectives, methods, and data privacy measures, with forms available in Hindi and English languages to ensure accessibility.

B. Participants

The study enrolled 122 preterm calculated using G-power software low-birth-weight neonates consecutively admitted to the NICU. Each infant was assigned a unique code to protect their identity and comply with data security regulations. The inclusion criteria were:

- Admission to the NICU within the study timeframe.
- Gestational age ≤36 weeks, verified by 1st Trimester ultrasound.
- Birth weight ≤2.000 kg, recorded at birth.
- Fully completed case record form.

Exclusion criteria included:

- Records with missing or unverified data, to ensure analytical accuracy.
- Infants transferred to other facilities before data collection, preventing complete assessment.
- Infants with major congenital anomalies (e.g., severe heart defects), which could distort characteristic distributions.

C. Data Collection

A Case record form was developed and tested in a pilot phase with 15 infants to confirm its reliability and usability.

The researcher gathered the data during routine clinical evaluations.

D. Statistical Analysis

Analyses were performed using SPSS 22 version. The chi-square goodness-of-fit test assessed whether observed frequencies deviated from an expected equal distribution. The null hypothesis (H_0) assumed uniform distribution across categories, while the alternative (H_1) suggested otherwise.

Expected frequencies were calculated as:

- *Age at Admission:* 122 / 4 = 30.5 (4 categories).
- *Sex:* 122 / 2 = 61 (2 categories).
- *Birth Weight:* 122 / 4 = 30.5 (4 observed categories).
- *Gestational Age:* 122 / 4 = 30.5 (4 categories).
- *Feeding Methods:* 122 / 3 ≈ 40.67 (3 categories).

E. Data Quality Assurance

The researcher collected the data to ensure correct documentation of all details of the study participants.

F. Ethical Considerations

The study complied with ethical principles, including:

- *Consent:* Guardians provided informed consent after detailed briefings, with multilingual support to ensure comprehension.
- *Privacy:* Data were anonymized, stored on encrypted servers, and accessible only to authorized personnel.
- *Voluntary Participation:* Guardians could withdraw without affecting care, with no withdrawals reported.

III. Results

Chi-square goodness-of-fit tests were applied to examine the distribution of clinical characteristics among 122 preterm low-birth-weight neonates, providing a clear picture of their demographic and clinical makeup. The results, summarized in Table I, include frequency, pecentage, chi-square values, degrees of freedom, and p-values for each characteristic.

Table I: Chi-Square Goodness-of-Fit Test Results for Neonatal Characteristics (N=122)

Variable	*Category*	*Frequency*	*Percentage (%)*	*Chi-Square*	*Degrees of Freedom*	*p-Value*
Age at Admission	4–6 days	32	26.2	0.39	3	0.9419
	7–9 days	31	25.4			
	10–12 days	28	23.0			
	>12 days	31	25.4			
Sex	Male	65	53.3	0.52	1	0.4693
	Female	57	46.7			

Variable	*Category*	*Frequency*	*Percentage (%)*	*Chi-Square*	*Degrees of Freedom*	*p-Value*
Birth Weight	1.201–1.400 kg	52	42.6	20.10	3	0.0002
	1.401–1.600 kg	27	22.1			
	1.601–1.800 kg	22	18.0			
	1.801–2.000 kg	21	17.2			
Gestational Age	28+1–30 weeks	27	22.1	0.72	3	0.8678
	30+1–32 weeks	31	25.4			
	32+1–34 weeks	33	27.0			
	34+1–36 weeks	31	25.4			
Feeding Methods	Breastfeeding	42	34.4	0.20	2	0.9048
	Formula feeding	39	32.0			
	Both	41	33.6			

Distribution and Statistical Outcomes

- *Age at Admission:* About 26% neonates were 4–6 days old, 25% were 7–9 days, 23% were 10–12 days, and another 25% were older than 12 days. The chi-square test showed a p-value of 0.9419, which means there's no significant difference in age distribution.
- *Sex:* The neonates were almost evenly split between boys and girls, with 53% being male and 47% female. The p-value of 0.4693 shows no big difference between the number of boys and girls.
- *Birth Weight:* The neonates' weights varied more noticeably. The largest group i.e. about 43%weighed between 1.201–1.400 kg, followed by 22% at 1.401–1.600 kg, 18% at 1.601–1.800 kg, and 17% at 1.801–2.000 kg. The chi-square test gave a p-value of 0.0002, which is very low. This means the differences in weight groups are statistically significant—there are more babies in the lower weight range than expected, which could signal a need for specific NICU resources for these tinier babies.
- *Gestational Age:* About 22% were born at 28+1–30 weeks, 25% at 30+1–32 weeks, 27% at 32+1–34 weeks, and 25% at 34+1–36 weeks. The p-value of 0.8678 suggests these groups are evenly spread out, with no significant differences.
- *Feeding Methods:* About 34% neonates were breastfeeding followed by 32% formula feed, and 34% both. The p-value of 0.9048 shows that these feeding methods are distributed evenly, with no one method being used significantly more than the others.

IV. Discussion

This study employed chi-square goodness-of-fit tests to analyze the clinical characteristics of 122 preterm low-birth-weight neonates, revealing key patterns in their distribution. The marked concentration of birth weights in the 1.201–1.400 kg range (42.6%, chi-square=20.10, df=3, p=0.0002) was a defining feature, signalling a non-uniform distribution. This finding echoes global patterns, where infants in the 1.0–1.5 kg range benefit from improved survival due to innovations like surfactant therapy and advanced ventilatory support (Liu et al., 2019). The clustering may also reflect the NICU's role as a referral center, receiving infants who survive initial stabilization elsewhere [2].

Conversely, the equitable distributions of age at admission (23.0%–26.2%, p=0.9419), sex (53.3% male, p=0.4693), gestational age (22.1%–27.0%, p=0.8678), and feeding methods (32.0%–34.4%, p=0.9048) indicate a diverse cohort, enhancing its relevance for preterm research. The balanced age distribution suggests steady admission patterns, with infants entering the NICU at various post-birth intervals, likely due to direct births or transfers. The slight male majority aligns with studies noting higher preterm birth rates in males, possibly linked to slower organ maturation [5]. The gestational age spread, peaking slightly at 32+1–34 weeks, covers a range from very to late preterm, supporting broad applicability [3]. The even feeding method distribution reflects a practical nutritional approach, balancing breast milk's benefits with formula's accessibility for infants with feeding challenges [6].

A. Clinical Implications

The birth weight concentration has significant implications for NICU operations:

- *Equipment Needs:* The 1.201–1.400 kg group requires tailored incubators (33–35 °C, 65–75% humidity) and feeding systems to support thermal and nutritional needs.
- *Infection Prevention:* These infants' vulnerability to infections necessitates rigorous measures, such as sterile procedures and limited visitor contact, to reduce sepsis risks.
- *Nutritional Support:* The reliance on formula (32.0%) and mixed feeding (33.6%) highlights barriers to exclusive breastfeeding, requiring enhanced lactation programs or

fortified formulas.

- *Monitoring:* Continuous monitoring for respiratory (e.g., oxygen saturation) and cardiac (e.g., heart rate variability) issues is critical, with automated systems to alert staff to anomalies.
- *Staff Development:* Training on managing moderate low-birth-weight infants, including skin-to-skin care and non-invasive ventilation, is essential to optimize care.

B. Research Implications

The findings open multiple research avenues:

- *Causes of Weight Clustering:* Exploring whether the 1.201–1.400 kg trend stems from genetic, clinical, or referral factors, potentially through multi-center studies.
- *Long-Term Effects:* Assessing how birth weight distribution affects growth, cognitive development, or healthcare utilization, using longitudinal cohorts.
- *Cross-NICU Comparisons:* Comparing distributions across diverse NICUs to identify variations and inform global preterm care strategies.
- *Nutritional Studies:* Investigating breastfeeding promotion versus formula fortification, with trials to evaluate impacts on health outcomes.
- *Predictive Analytics:* Developing models to predict complications based on birth weight and gestational age, leveraging data science techniques.

C. Literature Context

The birth weight concentration aligns with Liu *et al.*, who noted a prevalence of 1.0–1.5 kg infants in tertiary settings, driven by improved care. The balanced sex distribution matches Peelen *et al*., reporting slight male predominance in preterm births. Gestational age findings are consistent with Ancel *et al.*, though some studies highlight more very preterm infants in specialized NICUs. Feeding patterns echo Lessen *et al.*, noting 30–40% formula use due to breastfeeding difficulties.

D. Limitations

The study has limitations to consider:

- *Descriptive Scope:* Chi-square tests do not explore inter-characteristic relationships, limiting insights into, e.g., birth weight–gestational age links.
- *Single-Site Study:* Findings from one NICU may not apply to other settings with different patient profiles or resources.
- *Missing Contextual Data:* Lack of maternal or socioeconomic data restricts understanding of distribution drivers.
- *Sample Size:* The 122-infant sample, while sufficient, may limit precision for multi-category variables.
- *Equal Distribution Assumption:* Assuming uniform expected counts may oversimplify clinical expectations, such as natural sex ratio variations.
- *Cross-Sectional Design:* Cross sectional data miss changes over time, like evolving feeding practices.

E. Future Directions

Future studies should:

- Use relational statistical methods to explore characteristic interactions.
- Conduct multi-site research for broader applicability.
- Include maternal and environmental factors to explain distributions.
- Test non-uniform expected distributions for more realistic chi-square analyses.
- Adopt longitudinal designs to track characteristic changes.
- Evaluate targeted interventions for moderate low-birth-weight infants.
- Explore global preterm distribution patterns to inform policy.

V. Conclusion

This chi-square analysis of 122 preterm low-birth-weight neonates reveals a significant birth weight concentration at 1.201–1.400 kg and balanced distributions for age, sex, gestational age, and feeding methods. The weight trend highlights the need for specialized NICU resources, while the even distributions suggest a versatile cohort for preterm research. These findings provide a robust basis for clinical planning and scientific inquiry, advancing care for preterm infants.

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