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Neonatal Hypoxemia in the Neonatal Unit of the Albert Royer National Children's Hospital in Dakar (Chnear)

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Abstract

Introduction: Neonatal hypoxemia corresponds to a decrease in oxygen saturation, defined here as $SpO_2 \leq 94\%$ in room air, measured by pulse oximetry and interpreted in conjunction with the initial clinical assessment (Silverman score and signs of respiratory distress). Methods: This was a single-center retrospective observational study with descriptive and comparative analyses, conducted in a Level III neonatal unit at a university hospital from January 1 to December 31, 2024. Pulse oximetry was systematically performed at admission in hospitalized newborns and repeated according to clinical status. All newborns aged 0 to 28 days hospitalized with hypoxemia at admission ($SpO_2 \leq 94\%$ in room air) were included. Results: A total of 61 newborns were included, representing 14.73% of neonatal admissions. A slight female predominance was noted (57.38%). Most newborns were admitted within the first 24 hours of life (63.9%) and were referred from another facility (80.33%), most often by ambulance/medical transport (80.33%); low socioeconomic status was common (72.13%). More than half were preterm (54.1%), with a mean gestational age of 34.5 ± 5.1 weeks, and vaginal delivery was predominant (65.57%). At admission, respiratory distress was very common (93.4%), and 14.8% had severe forms (Silverman score > 6). The main diagnoses were neonatal infection (63.93%), prematurity (44.26%), hyaline membrane disease/respiratory distress syndrome (42.62%), congenital heart disease (27.87%), and perinatal asphyxia (21.31%). On chest imaging, cardiomegaly (8.2%) and thoracic hyperinflation (6.6%) were the most common abnormalities. Respiratory support relied mainly on nasal cannula oxygen therapy (59.02%), with use of CPAP (34.43%), endotracheal

intubation with mechanical ventilation (31.15%), and high-flow oxygen therapy (18.03%). The mean maximum FiO_2 administered reached 95.54%, with a median duration of oxygen therapy of 7 days and a median minimum oxygen saturation of 87%. Outcomes were unfavorable in 63.9% of cases, corresponding to 39 deaths; 22 newborns (36.1%) were discharged alive. Deaths were mainly attributed to neonatal infection (69.23%), followed by hyaline membrane disease (43.58%) and shock-related causes (28.20%; septic shock 15.38% and cardiogenic shock 12.82%). Conclusion: Neonatal hypoxemia in our unit remains frequent and severe, driven by prematurity, infection, and respiratory distress, and is associated with high mortality. These findings highlight the need for early detection through systematic pulse oximetry, safe medical transport, structured oxygen therapy protocols (nasal cannula/CPAP/HFNC/ventilation), effective infection control, and rapid access to echocardiography when congenital heart disease is suspected.

Keywords

Neonatal Hypoxemia, Respiratory Distress, Oxygen Therapy

1. Introduction

Neonatal hypoxemia refers to a decrease in blood oxygenation as measured by pre- and post-ductal pulse oximetry and blood gas analysis; it is distinct from tissue hypoxia, in which cellular distress persists despite sometimes normal PaO_2 levels [1]-[3]. Its severity is assessed by SpO_2, the oxygenation index, and the response to the hyperoxia test, while its pathophysiology is based on intra- or extrapulmonary right-to-left shunts associated with pulmonary pathologies, PAH, or duct-dependent cyanotic heart diseases. Epidemiologically, African data and a global metaanalysis show a high prevalence among hospitalized newborns, ranging from 16% to 30% in Africa and approximately 25% globally, with a strong association with mortality [4]-[6]. Management aims for a delicate balance between correcting hypoxemia and preventing hyperoxia, prioritizing CPAP and less invasive surfactant strategies, and reserving iNO, sildenafil, or PGE_1 for complicated cases [7]-[10]. In this context, our study aims to describe the hospital admission rate, clinical and etiological determinants, and the outcomes of newborns managed for hypoxemia.

2. Methods

This was a retrospective observational study with descriptive and comparative analyses conducted in the neonatology department of the Albert Royer National Children's Hospital (CHNEAR) in Dakar over a 12-month period, from January 1 to December 31, 2024. The CHNEAR is a Level III pediatric referral hospital equipped with a neonatal intensive care unit, a conventional neonatology unit,

and a kangaroo care unit, providing care for high-risk newborns, particularly those with respiratory distress. Data were collected from hospitalization records, medical charts, and monitoring sheets for all newborns admitted for hypoxemia during the study period. Pulse oximetry was performed systematically at admission in all hospitalized newborns, using pre- and/or post-ductal measurements when clinically indicated, and was repeated according to clinical status and response to oxygen therapy. The exact pulse oximeter model was not consistently recorded in the medical charts. Blood gas analysis was performed when available, but it was not systematic for all newborns.

The study comprehensively included newborns aged 0 to 28 days, hospitalized in the neonatal unit, presenting with hypoxemia at admission defined as oxygen saturation (SpO_2) ≤ 94% on room air, measured by pulse oximetry. Records that were incomplete, illegible, or did not allow confirmation of SpO_2 at admission or hospital outcome were excluded. The study sample therefore corresponds to all documented cases of hypoxemia during the study period. Maternal and obstetric variables included maternal age, parity, medical history, prenatal care, pregnancy-related conditions (hypertension, infections, diabetes, blood disorders, etc.), and delivery characteristics (place of delivery, mode of delivery, and transfer conditions). The neonatal characteristics analyzed at admission were gestational age, birth weight, sex, Apgar score, body temperature, vital signs, Silverman score, signs of respiratory distress (chest-abdominal retraction, grunting, and retractions), and other associated clinical manifestations (hemodynamic, neurological, and infectious disorders). Laboratory and imaging data included pre- and post-ductal oxygen saturation, chest X-ray, routine laboratory tests (complete blood count, CRP, blood glucose, blood gases when available), and additional tests performed to determine the etiology (echocardiography, blood cultures, etc.). Respiratory support modalities were described in detail: type of oxygen therapy (oxygen mask or nasal cannula, CPAP, mechanical ventilation, high-flow oxygen therapy, or other devices), maximum inspired oxygen fraction (FiO_2), duration of oxygen therapy, and need for therapeutic escalation. Etiological diagnoses were grouped into broad categories: neonatal infection, respiratory distress syndrome/hyaline membrane disease in preterm infants, perinatal asphyxia, congenital heart disease, malformative or metabolic disorders, and other causes.

The main operational definitions were: hypoxemia (SpO_2 ≤ 94% on room air), significant respiratory distress (Silverman score > 3), severe respiratory distress (Silverman score > 6), abnormal pre-/post-ductal saturation gradient (difference ≥ 5%), hypothermia (temperature < 36˚C), and fever (temperature ≥ 38˚C). Outcome was coded as discharge alive or death during hospitalization. Non-weaning from oxygen was recorded when oxygen support could not be stopped before death. When several diagnoses were present, the cause of death was attributed to the dominant clinical diagnosis documented in the medical record. Data were collected using a standardized data collection form developed specifically for the

study. Quality control was performed by cross-checking information across registries, medical records, and paraclinical reports to minimize transcription errors and reduce information bias related to the retrospective design. No sample size calculation was performed beforehand; the study included all eligible cases during the study period.

Statistical analysis included descriptive and comparative analyses. Qualitative variables were presented as frequencies and percentages. Quantitative variables were expressed as mean ± standard deviation or as median with minimum and maximum ranges, depending on their distribution. Comparisons were performed according to clinical outcome (death versus survival), with a significance threshold set at $p < 0.05$. Data processing was performed using IBM SPSS Statistics software (version 23) and Microsoft Excel. From an ethical standpoint, the study was based on the secondary use of routine clinical data, without any additional intervention. Data were anonymized before entry and analysis. Authorization was obtained from the hospital administration and the neonatology department, in accordance with confidentiality requirements and the principles of the Declaration of Helsinki.

3. Results

Participants. Of 414 neonatal admissions during the study period, 61 newborns presented with hypoxemia, representing a hospital prevalence of 14.73%. Admissions occurred primarily within the first 24 hours of life. The majority of newborns were referred from another facility (80.33%), and transport was most often provided by ambulance/medical transport (80.33%) (Table 1).

Descriptive data. A monthly peak was observed in January (26/61; 42.6%). Most mothers were aged 20 - 35 years (45/61; 73.77%). The most common place of origin was Dakar (68.85%), and the majority were from low socioeconomic backgrounds (72.13%). A slight female predominance was noted (57.38%), with a sex ratio of 0.74. From an obstetric perspective, nulliparous women (42.6%) and women with few previous pregnancies (39.3%) were predominant. The majority of mothers reported neither a history of abortion (83.6%) nor known comorbidities (88.52%). When a history existed, hypertension and gestational diabetes were the most commonly cited (3.28% each). The pregnancy was most often singleton (90.16%). Prenatal care varied, with 1 to 4 prenatal visits in 57.38% of cases. The majority of women had undergone a single ultrasound examination (50.8%) (Table 1).

At birth, 54.1% of newborns were preterm. By gestational age group, 34.4% were < 32 weeks, 19.7% were 32 - 36 weeks, 39.3% were 37 - 40 weeks, and 6.6% were ≥ 40 weeks, with a mean gestational age of 34.5 ± 5.1 weeks (range 25 - 43 weeks). Vaginal delivery was the most common mode of delivery (65.57%). At admission, intrauterine growth restriction (IUGR) was found in 24.5% of cases and low birth weight in 59%. Median measurements were: birth weight 1900 g, length 45 cm, and head circumference 30 cm (Table 2).

Table 1. Sociodemographic and obstetric characteristics of mothers (N = 61).

Variable	Category	Sample Size (n)	Percentage (%)
Geographic origin	Dakar	42	68.85
	Other regions	19	31.15
Socioeconomic status	Low	44	72.13
	Medium/High	17	27.87
Maternal age	20 - 35 years	45	73.77
	<20 years or >35 years	16	26.23
Gravidity	Primigravida	16	26.2
	Secundigravida/Multigravida (2 - 4 pregnancies)	26	42.6
	Grand multigravida (≥5 pregnancies)	19	31.1
Parity	Primiparous	19	31.1
	Multiparous (2 - 4 deliveries)	24	39.3
	Grand multiparous (≥5 deliveries)	18	29.5
Type of pregnancy	Singleton	55	90.16
	Twin	6	9.84
Number of antenatal care visits (ANC)	0	2	3.28
	1 - 4	35	57.38
	>4	21	34.43
	Not specified	3	4.92
Number of ultrasound examinations	0	7	11.5
	1	31	50.8
	2	17	27.9
	3	4	6.6
	≥4	2	3.2
History of abortion	Yes	10	16.4
	No	51	83.6
Maternal comorbidities*	No known comorbidity	54	88.52
	Hypertension	2	3.28
	Gestational diabetes	2	3.28
	Heart disease	1	1.64

*Maternal comorbidities were not mutually exclusive; some mothers had more than one condition.

Table 2. Neonatal characteristics and clinical findings at admission (N = 61).

Variable	Category	Sample Size (n)	Percentage (%)
Sex	Female	35	57.38
	Male	26	42.62

Continued

Gestational age	<32 weeks	21	34.4
	32 - 36 weeks	12	19.7
	37 - 40 weeks	24	39.3
	>40 weeks	4	6.6
	Mean ± SD	**34.5 ± 5.1 weeks**	**Range: 25 - 43 weeks**
Prematurity	Yes	33	54.1
	No	28	45.9
Growth status (trophicity)	Intrauterine growth restriction (IUGR)	15	24.5
	No IUGR	46	75.5
Birth weight	<2500 g (low birth weight)	36	59.0
	≥2500 g	25	41.0
	Median birth weight	**1900 g**	–
Mode of admission	Referred from another facility	49	80.33
	Direct admission from home	10	16.39
	Other/unspecified	2	3.28
Means of transportation	Ambulance	49	80.33
	Other	12	19.67
Vital signs at admission	Hypothermia	23	37.7
	Tachypnea	21	34.4
	Bradycardia	17	27.9
	Tachycardia	12	19.7
	Hypotension*	10	16.4
	Fever	5	8.2
	Hypoglycemia	5	8.2
	Pre-ductal SpO_2 < 90%	24	39.3
	Post-ductal SpO_2 < 80%	16	26.2
Clinical signs at admission	Respiratory distress	57	93.4
	Hypotonia/lethargy	15	24.6
	Associated congenital malformations	13	21.3
	Refusal to breastfeed	12	19.7
	Cyanosis	9	14.8
	Seizures	9	14.8
	Shock	3	4.9

*The value reported as 10 cases (16.4%) was presumed to correspond to hypotension, as bradycardia was already listed above. This should be verified against the original dataset.

Outcome data. The outcome was unfavorable in 63.9% of cases, corresponding to 39 deaths out of 61 newborns; 22 newborns (36.1%) were discharged alive. Fail-

ure to wean from oxygen concerned the same 39 newborns who died before oxygen support could be discontinued.

Main results. At admission, hypoxemia was often severe: pre-ductal SpO_2 was < 90% in 39.3% of cases, and post-ductal SpO_2 was < 80% in 26.2% of cases. Respiratory distress was present in 93.4% of newborns, and severe respiratory distress (Silverman score > 6) was observed in 14.8%.

Biological abnormalities were interpreted in relation to the retained clinical diagnosis. Anemia (26.2%) and leukocytosis (16.4%) were mainly observed in newborns with infection, prematurity, or hemodynamic compromise, whereas hyperbilirubinemia (14.8%) was more frequent in preterm infants. Chest X-ray findings were also analyzed according to diagnosis: cardiomegaly was mainly associated with congenital heart disease, thoracic hyperinflation or distension with respiratory distress, and focal radiological abnormalities with suspected infection. Overall, the most common diagnoses were neonatal infection (63.93%), prematurity (44.26%), and hyaline membrane disease/respiratory distress syndrome (42.62%). Congenital heart disease was found in 27.87% of cases, and perinatal asphyxia in 21.31%. The most common heart diseases were patent ductus arteriosus (PDA) and atrial septal defect (ASD) (8.2% each).

Regarding respiratory support, the most commonly used modality was nasal cannula oxygen therapy (59.02%), followed by CPAP (34.43%), endotracheal intubation with mechanical ventilation (31.15%), bag-valve mask ventilation (21.31%), and high-flow oxygen therapy (18.03%). The maximum FiO_2 most often

Table 3. Comparison of qualitative variables according to clinical outcome in neonates with hypoxemic respiratory failure.

Variable	Category	Death, n (%)	Survival, n (%)	p-value
Sex	Female	19	14	0.119
	Male	20	6	
Admission source	Referred from another facility	36	13	0.008
	Admitted from home	3	7	
Intrauterine growth restriction (IUGR)	Yes	5	9	0.003
	No	33	9	
Respiratory distress	Yes	39	17	0.013
	No	0	3	
Congenital heart disease	Yes	10	6	0.721
	No	29	14	
Prematurity	Yes	17	9	0.690
	No	19	8	
Persistent pulmonary hypertension of the newborn (PPHN)	Yes	27	11	-
	No	-	-	-

Abbreviations: IUGR, intrauterine growth restriction; PPHN, persistent pulmonary hypertension of the newborn. *Statistically significant associations* ($p < 0.05$) *were observed for admission source, IUGR, and respiratory distress.*

reached 100% (median 100%; mean 95.54%). The median duration of oxygen therapy was 7 days, and the median duration of hypoxemia was 6 days. The most common treatments were maintenance fluids (96.72%), enteral/parenteral nutritional support (83.61%), and antibiotics (67.21%).

Comparative analyses showed significant associations between clinical outcome and admission source ($p = 0.008$), mode of transport ($p = 0.023$), intrauterine growth restriction status ($p = 0.003$), and respiratory distress ($p = 0.013$). Deceased infants were admitted earlier (44.68 h vs 114.75 h; $p < 0.0001$), were more

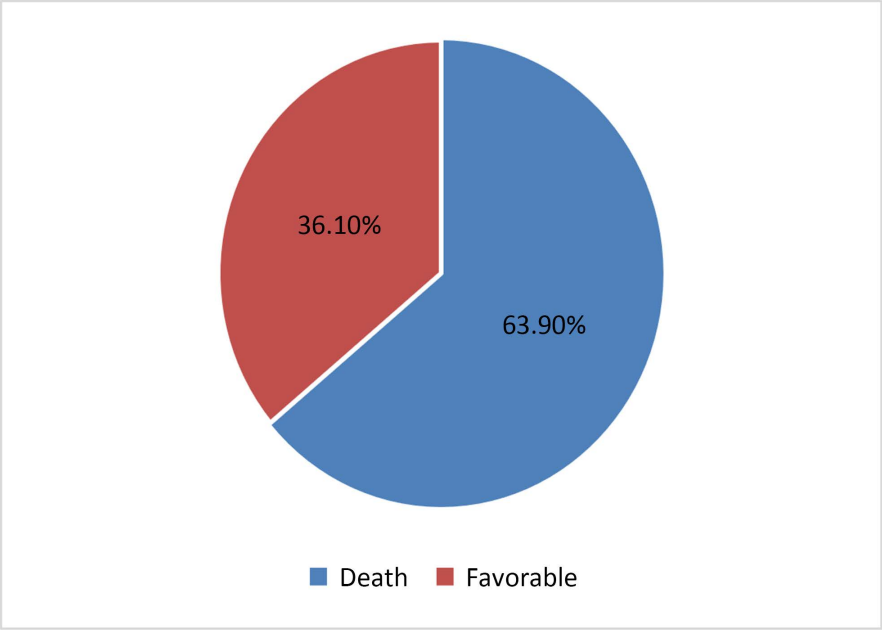

Figure 1. Distribution of outcomes (death vs. favorable outcome) among hypoxemic newborns.

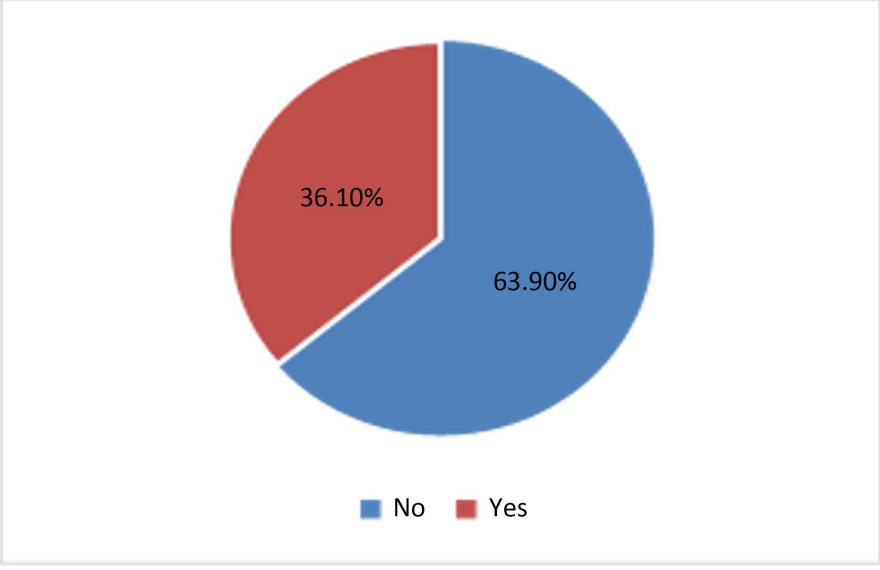

Figure 2. Distribution of hypoxemic newborns according to oxygen weaning during hospitalization.

immature (33.94 vs 35.73 weeks of gestational age; p = 0.005), required a higher maximum FiO_2 (98.97% vs 88.75%; p < 0.0001), and had lower post-ductal SpO_2 (80.66% vs 89.2%; p = 0.05) (**Table 3**). Among deaths (N = 39), the leading diagnoses were neonatal infection (69.23%), hyaline membrane disease (43.58%), and shock-related causes (28.20%; septic shock 15.38% and cardiogenic shock 12.82%) (**Figure 1** and **Figure 2**).

4. Discussion

The hospital incidence of neonatal hypoxemia varies depending on the referral level, organization of care, availability of oxygenation resources, and seasonality of infections. At the population level, North American registries report rare cases of asphyxia/hypoxemia (≈2.28/1000 births ≥ 35 weeks' gestation) [11], whereas tertiary-care series describe a higher burden among hospitalized newborns and in-hospital mortality approaching 18% [12] [13]. In our Level III neonatal unit, 61 newborns were admitted during the study year for documented hypoxemia or hypoxemic respiratory distress, representing 14.73% of neonatal admissions. A clear monthly peak was observed in January (26/61; 42.6%), and the quarterly distribution decreased from Q1 (42.6%) to Q4 (13.1%). This pattern does not fully reflect the rainfall-dependent trend described in Maputo [14] but rather aligns with temporal heterogeneity observed in hospital registries [11] [15] [16], with direct implications for planning oxygen supply, beds, and consumables during high-burden periods.

From an etiological perspective, the literature primarily cites pulmonary immaturity/hyaline membrane disease, early neonatal infection (pneumonia/sepsis), perinatal asphyxia, persistent pulmonary hypertension of the newborn (PPHN), and congenital heart defects, particularly duct-dependent lesions [12] [13] [17]-[21]. Our results confirm a predominance of respiratory-infectious causes: neonatal infection (63.93%), prematurity (44.26%), and hyaline membrane disease (42.62%), followed by perinatal asphyxia (21.31%) and polymalformative syndromes (16.39%). Congenital heart defects were identified in 27.87% of cases, dominated by PDA and ASD (8.2% each), but also including lesions causing greater desaturation (transposition of the great vessels 4.92%, coarctation 4.92%, left ventricular hypoplasia 1.64%, and aortic arch interruption 1.64%). This profile, in which infectious causes and immaturity play a greater role than major structural anomalies, contrasts with ECMO-oriented registries where severity is often defined by severe congenital cardiorespiratory defects [15] [16], while remaining consistent with large series reporting 10% - 19% congenital anomalies among cases of neonatal respiratory distress [12] [13]. The use of prostaglandins (8.2%) and sildenafil (4.92%) supports the presence of a subgroup with PPHN and/or duct-dependent physiology, where early echocardiography becomes central to therapeutic decision-making [19] [22].

This etiological hierarchy is understandable in light of the risk factors identified. The literature highlights, during the antenatal period, the role of prematurity, IUGR, maternal comorbidities (hypertension/diabetes), premature rupture of

membranes, chorioamnionitis, and inadequate prenatal care [11] [18] [23] [24]. Our maternal population was predominantly young (27.8 ± 6.4 years; 60.6% ≤ 30 years), a profile similar to reports from comparable settings [24] [25]. Prenatal care coverage was moderate (57.38% with 1 - 4 visits and 34.43% with > 4 visits), with limited antenatal imaging, which may have contributed to the burden of prematurity and IUGR. In the peripartum period, vaginal delivery predominated (65.57%), and delivery-room resuscitation was required in 47.54% of cases, while absence of cry was reported in 42.62%, indicating perinatal stress. Neonatally, the cohort was characterized by high prematurity (54.1%, including 34.4% < 32 weeks' gestation), low median birth weight (1900 g), and frequent hypothermia at admission, all of which are recognized markers of vulnerability in resource-limited neonatal units.

Clinical presentation was dominated by respiratory distress (93.4%). Cyanosis was less frequent (14.8%), underscoring the importance of systematic pulse oximetry, since clinical assessment alone may miss significant desaturation. The mean pre- and post-ductal SpO_2 values (85.6% and 83.3%), with 39.3% of pre-ductal values < 90% and 26.2% of post-ductal values < 80%, indicate severe hypoxemia. The pre-/post-ductal gradient supports the hypothesis of right-to-left shunting and PPHN in some newborns, justifying targeted echocardiography according to consensus recommendations [19] [22]. Laboratory abnormalities (anemia, leukocytosis, hyperbilirubinemia, electrolyte disturbances, and elevated creatinine when present) and chest X-ray findings (cardiomegaly, thoracic distension, or focal signs of infection) were nonspecific but consistent with infectious, respiratory, cardiac, or multisystemic hypoxic stress.

Therapeutically, management was multimodal: nasal cannula oxygen therapy (59.02%), CPAP (34.43%), invasive ventilation (31.15%), bag-valve mask ventilation (21.31%), and high-flow oxygen therapy (18.03%). The very high mean maximum FiO_2 (95.54%), median duration of oxygen therapy (7 days), and median duration of hypoxemia (6 days) reflect marked initial severity and prolonged oxygen dependence. Current recommendations emphasize explicit SpO_2 targets, cautious FiO_2 titration, prevention of harmful hyperoxia, and use of indices such as the oxygen saturation index to monitor severity [15] [16] [19] [22] [26]. In settings with constrained resources, standardized protocols for oxygen initiation, escalation, weaning, equipment maintenance, infection prevention, and early referral are particularly important to reduce avoidable mortality. The core treatment regimen combined fluid therapy, nutritional support, antibiotics (67.21%), and caffeine (36.07%), with adjunctive therapies selected according to pathophysiology (vasoactive agents, prostaglandins, and sildenafil).

Finally, the literature reports hospital mortality for neonatal hypoxemic respiratory failure ranging from 8% to 26%, depending on severity and access to life-saving therapies [12] [15] [16] [20] [21]. Our mortality rate (63.9%), dominated by refractory hypoxemia and deaths primarily related to infection, hyaline membrane disease, and shock-related causes, suggests a combination of initial severity,

infectious burden, immaturity, and limited rescue resources. Interventions most directly aligned with our findings include reduction of the hypoxic burden through SpO_2/FiO_2-guided management and protocol-based weaning [22] [23] [26], cardiopulmonary coordination through early echocardiography and PPHN/duct-dependence algorithms [19] [22], and stepwise ventilation favoring non-invasive methods whenever appropriate, together with infection control and nutritional optimization [13] [27].

5. Study Limitations

This study has several limitations. Its retrospective and single-center design limits the generalizability of the findings and exposes the analysis to missing or incomplete data. Some variables requested by reviewers, such as the exact delay from symptom onset to referral, detailed nutritional status, immunodeficiency status, systematic blood gas values, and the exact pulse oximeter model, were not consistently available in the medical records. The attribution of cause of death was based on the dominant clinical diagnosis documented in the file, which may be difficult in newborns with multiple associated conditions. Despite these limitations, the study provides a pragmatic description of severe neonatal hypoxemia in a Level III referral unit and identifies actionable areas for improvement in early detection, oxygen therapy, infection control, transport, and access to echocardiography.

6. Conclusion

Neonatal hypoxemia emerges in our study as a major public health issue, concentrated at the beginning of the year and primarily affecting preterm infants referred early from disadvantaged backgrounds, with severe respiratory distress and profound hypoxemia from the outset. Despite multimodal oxygen therapy and management strategies combining nutritional support, antibiotics, and adjuvant therapies, mortality remains very high, driven primarily by refractory hypoxemia, neonatal infection, hyaline membrane disease, and shock-related causes. These findings support the need to strengthen monitoring capabilities through routine pulse oximetry, oxygenation resources (CPAP, high-flow oxygen, and mechanical ventilation), early echocardiography, and strict protocols for oxygen titration and weaning. They also emphasize the importance of improving prenatal care, safe referral and transport, infection prevention, and family education.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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