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Original Research Article

Oxygen Saturation in Severe Malnutrition

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Abstract: *Severe malnutrition remains a major cause of childhood morbidity and mortality in low- and middle-income countries. Hypoxemia is a strong predictor of mortality, yet it is often underrecognized in malnourished patients.* ***Objective:*** *To assess oxygen saturation levels in patients with severe malnutrition and to determine associated clinical factors, including pneumonia and anemia.* ***Methodology:*** *This cross-sectional analytical study was conducted at Abbasi Shaheed Hospital, Karachi, from February 1, 2024, to January 31, 2025. A total of 185 patients with severe malnutrition, as defined by World Health Organization criteria, were enrolled using a non-probability consecutive sampling method. Oxygen saturation was measured using a standardized pulse oximeter at the time of admission. Demographic and clinical data, including the presence of anemia and pneumonia, were recorded.* ***Results:*** *The mean age of participants was 3.8 ± 1.6 years, with 55.1% males and 44.9% females. Marasmus was present in 59.5% of cases, while 40.5% had kwashiorkor. The mean oxygen saturation at admission was 91.4% ± 4.2. Hypoxemia (SpO_2 <90%) was observed in 33.5% of patients. Children with pneumonia demonstrated significantly higher rates of hypoxemia compared to those without pneumonia (47.8% vs. 24.2%, p = 0.01). Anemia was also significantly associated with low oxygen saturation (39.7% vs. 21.9%, p = 0.03). Younger children (<2 years) showed a higher prevalence of hypoxemia (40.0%) compared to older age groups.* ***Conclusion:*** *It is concluded that hypoxemia is frequent among patients with severe malnutrition, particularly in those with pneumonia, anemia, and younger age. Routine pulse oximetry should be integrated into the assessment of malnourished patients to enable early detection and timely oxygen therapy. Addressing coexisting infections and anemia alongside nutritional rehabilitation may reduce preventable mortality.*

Keywords: Hypoxemia, Patients, Morbidity, Nutrient, Poverty, Food insecurity

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Introduction

Severe malnutrition remains one of the most pressing health challenges in developing countries, where poverty, food insecurity, and inadequate healthcare access converge to create high burdens of morbidity and mortality among children (1). Millions of children under the age of five are facing acute malnutrition on a global scale, and severe acute malnutrition (SAM) is claiming many hospitalizations and deaths. Malnutrition is not only an indication of an inadequate diet, but also a response to infection, inadequate immune status, and systemic physiological stress. Hence, malnutrition is both a factor and a result of ill health (2). Although the impacts of malnutrition on growth, the immune system, and developmental status are well-examined, its effect on oxygenation and breathing is relatively unexplored. Pulse oximetry-derived oxygen saturation is a direct measure of respiratory sufficiency and tissue oxygenation and can be an important indicator of illness severity among malnourished patients (3). A combination of various physiological changes brings on this change in oxygen saturation levels in cases of severe malnutrition. Wasting of the respiratory muscles is a significant consideration; loss of diaphragmatic and intercostal muscle strength interferes with the ventilatory process and can lead to hypoventilation (4). Meanwhile, the low pulmonary compliance associated with interstitial-related changes and frequent coexisting infection, including pneumonia and bronchiolitis, additionally worsens hypoxemia. Pneumonia is the most frequent sequela of malnourished children, and often it is accompanied by poor oxygen saturation (5). Due to the atypical or subtle signs of respiratory distress seen in malnourished children, exclusion of hypoxemia detection through clinical observation alone may cause a delay in its recognition (6). Pulse oximetry is, therefore, another useful instrument in early diagnosis and monitoring. The other factor is anemia, which occurs in virtually every patient in the highly malnourished group. Despite normal values of arterial oxygen saturation (SpO2), the lowered hemoglobin concentration dramatically reduces the oxygen-carrying capacity of blood, rendering tissue oxygen delivery ineffective (7). Dietary micronutrient deficits (iron, zinc, and vitamin A) exacerbate the situation by having a detrimental impact on hematopoiesis and immune competence. Besides, severe electrolytic disturbances, in particular hypokalemia and hypomagnesemia, can deteriorate heart contractility and aggravate local tissue hypoxia (8). Malnutrition, in fact, reduces cardiac output alone, a condition known as low-flow hypoxia, further impacting cellular oxygen delivery. The importance of oxygen saturation monitoring in malnourished patients extends beyond short-term lung performance (9). Hypoxemia has been identified as a factor that increases the risk of death of hospitalized children, independent of underlying diagnosis. In children affected by malnutrition, there is a risk of increased exposure due to deficient physiological reserves. It has been indicated that modest decreases in O_2 saturation can prove devastating when there is impaired nutrition (10). However, due to the lack of pulse oximetry and supplemental oxygen access in many low-resource settings where malnutrition is widespread, it is a preventable cause of death. Part of the World Health Organization (WHO) strategy is to achieve integrated management of childhood illness (IMCI), and this encourages red-flagging of hypoxemia as an indication that needs invasive interventions. The question of using oxygen saturation monitoring in malnourished populations, however, is not sufficiently addressed in the majority of guidelines. This loophole highlights the need for further research (11). Establishing the extent and severity of hypoxemia, as well as its prognostic and predictive potential, in children with malnutrition may provide vital information that can guide changes in the treatment paradigm. It would also be beneficial in determining which patients require urgent oxygenation, closer monitoring, or referral to specialized treatment centers (12).

Thus, the objective of the study was to assess oxygen saturation levels in patients with severe malnutrition and to determine associated clinical factors, including pneumonia and anemia.

Methodology

This was a cross-sectional analytical study conducted at Abbasi Shaheed Hospital, Karachi, a tertiary care teaching hospital, from February 1, 2024, to January 31, 2025. A total of 185 patients were enrolled in the study. The sample size was determined based on feasibility and the availability of eligible participants during the study period. Non-probability consecutive sampling was used to recruit patients who fulfilled the eligibility criteria.

Patients of all genders and age groups presenting with severe malnutrition, as defined by the World Health Organization (WHO) criteria (weight-for-height/length <-3 SD, presence of bilateral pedal edema, or mid-upper arm circumference <11.5 cm in children), were included in the study. Patients with known chronic pulmonary diseases, congenital or acquired heart diseases, and those with acute conditions that could independently affect oxygen saturation (e.g., acute asthma exacerbations, chronic obstructive pulmonary disease) were excluded to reduce confounding.

Upon admission, informed consent was obtained from patients or their guardians. A structured proforma was used to collect demographic data, clinical history, and relevant anthropometric measurements. Oxygen saturation was measured using a standardized, portable pulse oximeter, with the probe applied to the index finger (or the great toe in infants), after ensuring adequate perfusion. Measurements were taken at rest in room air and recorded as percentage values. Additional clinical parameters, including heart rate, respiratory rate, presence of comorbid infections, and hemoglobin levels, were documented.

Data were entered and analyzed using Statistical Package for the Social Sciences (SPSS) version 26. Descriptive statistics were applied to summarize the data. Continuous variables, such as age and oxygen saturation, were expressed as the mean ± standard deviation (SD). In contrast, categorical variables, including gender and the presence of hypoxemia, were presented as frequencies and percentages. The Chi-square test was applied to assess associations between categorical variables, while an independent t-test was used to compare means between groups. A p-value ≤0.05 was considered statistically significant.

Results

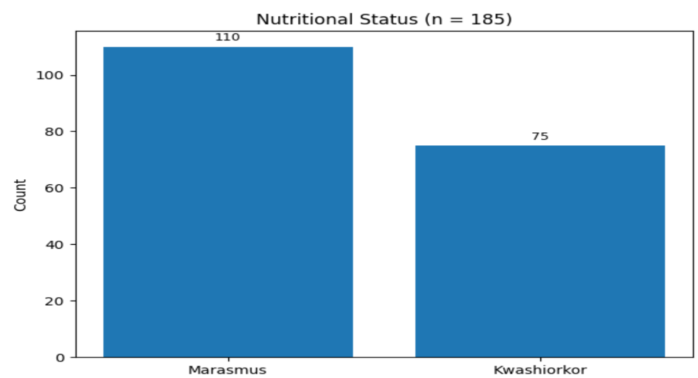
Data were collected from 185 patients. Most children were 2–5 years old (42.2%), with infants <2 years forming a sizeable 35.1%; only 22.7% were >5 years, so the cohort skews young. Males slightly predominated (55.1%). Marasmus was more frequent than kwashiorkor (59.5% vs 40.5%). Anemia was common (65.4%), and respiratory infection was present in over a third (37.3%). Oxygenation clustered in the 90–94% band (41.1%); adding <85% (9.7%) and 85–89% (23.8%) shows one-third (33.5%) met the hypoxemia threshold (SpO_2 <90%), while 25.4% were ≥95%.

Hypoxemia was markedly more frequent with pneumonia/ARI (47.8%) than without (24.2%), a statistically significant difference (p = 0.01), underscoring infection as a key driver of low SpO_2. Anemia showed a similar pattern: 39.7% of patients with anemia had hypoxemia compared to 21.9% without (p = 0.03).

Mean SpO_2 increased with age: 90.6% in infants (<2y), 91.8% in children (2–5y), and 92.4% in older children (>5y). Infants had the highest hypoxemia rate (40.0%), compared to 30.8% and 28.6% in older groups, respectively, with a significant trend (p = 0.04). By phenotype, kwashiorkor showed more hypoxemia than marasmus (40.0% vs 29.1%) and a slightly lower mean SpO_2 (91.0% vs 91.7%), but this difference did not reach statistical significance (p = 0.21).

Risk stacked sharply when anemia and pneumonia coexisted: hypoxemia affected **53.7%** in the dual-positive group (p < 0.001), far higher than anemia-only (28.4%), pneumonia-only (26.7%), or neither condition (20.4%). This interaction suggests synergism, not mere additivity, between impaired oxygen-carrying capacity and respiratory compromise.

Figure 1. Nutritional status of the study population



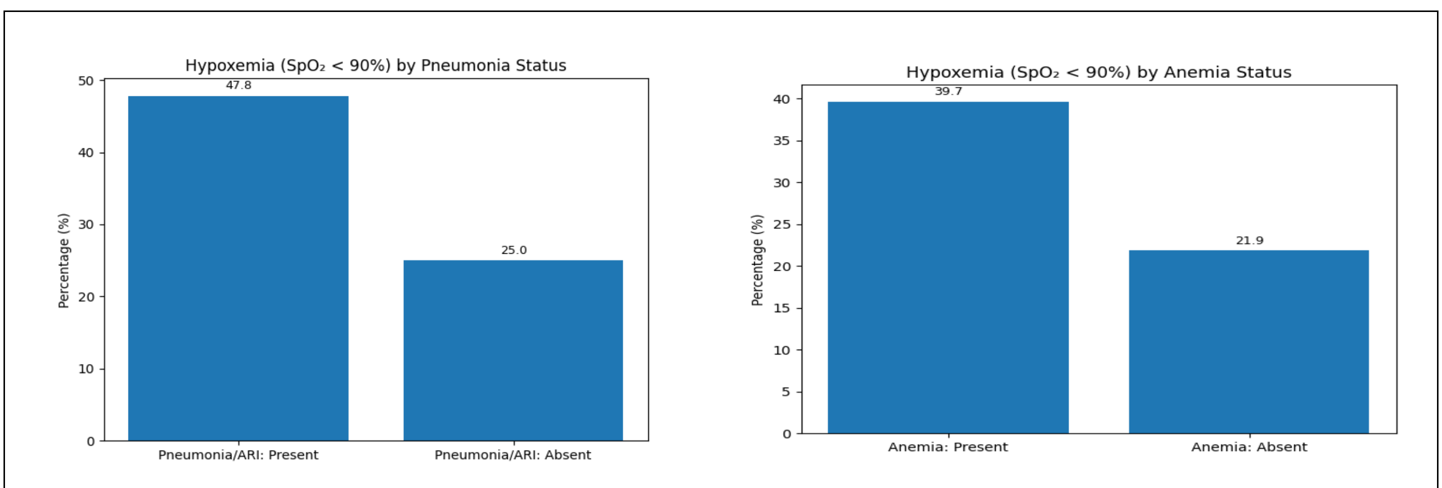


Figure 2: Hypoxemia status of the study population

Table 1: Baseline Demographic and Clinical Characteristics of Patients (n = 185)

Variable	Frequency (n)	Percentage (%)
Age Group		
< 2 years	65	35.1
2–5 years	78	42.2
> 5 years	42	22.7
Gender		
Male	102	55.1
Female	83	44.9
Nutritional Status		
Marasmus	110	59.5
Kwashiorkor	75	40.5
Associated Anemia	121	65.4
Respiratory Infection (Pneumonia/ARI)	69	37.3
Oxygen Saturation (SpO_2)		
< 85%	18	9.7
85–89%	44	23.8
90–94%	76	41.1
≥ 95%	47	25.4

Table 2: Association of Hypoxemia with Clinical Variables (n = 185)

Variable	Hypoxemia Present (SpO_2 <90%)	Hypoxemia Absent (SpO_2 ≥90%)	p-value
Pneumonia/ARI: Present	33 (47.8%)	36 (52.2%)	0.01*
Pneumonia/ARI: Absent	29 (24.2%)	87 (75.8%)	
Anemia: Present	48 (39.7%)	73 (60.3%)	0.03*
Anemia: Absent	14 (21.9%)	50 (78.1%)	

Table 3: Oxygen Saturation by Age Group (n = 185)

Age Group	Mean SpO_2 ± SD	Hypoxemia Present (n, %)	Hypoxemia Absent (n, %)	p-value
< 2 years (n = 65)	90.6 ± 4.5	26 (40.0%)	39 (60.0%)	0.04*
2–5 years (n = 78)	91.8 ± 3.9	24 (30.8%)	54 (69.2%)	
> 5 years (n = 42)	92.4 ± 3.6	12 (28.6%)	30 (71.4%)	
Nutritional Status				
Marasmus (n = 110)	91.7 ± 3.8	32 (29.1%)	78 (70.9%)	0.21
Kwashiorkor (n = 75)	91.0 ± 4.6	30 (40.0%)	45 (60.0%)	

Table 4: Combined Effect of Anemia and Pneumonia on Hypoxemia (n = 185)

Clinical Status	Hypoxemia Present (n, %)	Hypoxemia Absent (n, %)	p-value
Anemia + Pneumonia (n = 54)	29 (53.7%)	25 (46.3%)	<0.001*
Anemia without Pneumonia (n = 67)	19 (28.4%)	48 (71.6%)	
Pneumonia without Anemia (n = 15)	4 (26.7%)	11 (73.3%)	
No Anemia, No Pneumonia (n = 49)	10 (20.4%)	39 (79.6%)	

Discussion

The present study evaluated oxygen saturation levels in patients with severe malnutrition admitted to Abbasi Shaheed Hospital in Karachi over one year. Overall, about 33 percent of the 185 participants were hypoxic (SpO_2 <90%), with pneumonia and anemia pointed out as the notable clinical factors. These observations point out the acute susceptibility of malnourished children to respiratory failure and the usefulness of periodic oxygen surveillance in this at-risk population. The average oxygen saturation in our study cohort was 91.4% ± 4.2, with nearly one in 10 children having a SpO_2 of less than 85. This finding is in line with earlier studies that malnourished children, with their respiratory muscles weakened and a diminishment of pulmonary reserve, tend to be precariously oxygenated at rest and precipitously destabilize when infected. Pneumonia, diagnosed in 37.3% of our patients, also significantly increased the rates of hypoxemia (47.8% vs. 24.2%, without pneumonia, p = 0.01). This is consistent with previous studies that established that pneumonia is one of the main causes of death in severely malnourished children, mainly because of unrecognized or untreated hypoxemia. Anemia, seen in 65.4 percent of our patients, also showed a significant negative correlation with oxygen saturation (p = 0.03) (13). Although pulse oximetry measures hemoglobin oxygen saturation, not absolute oxygen content, extreme anemia impairs oxygen delivery at the tissue level, thereby increasing the clinical effects of relatively small decreases in SpO_2. The likelihood of anemia and malnutrition-induced hypoxia manifesting under synergistic influence has also been previously signified as causing increased levels of morbidity and mortality (14). Our data confirm this interaction, especially in anemia and pneumonia, where more than half of the patients (53.7%) showed hypoxemia. Analysis by age indicated that infants under age 2 years had a higher probability of hypoxemia than in older age groups (40.0% vs. 28 31%, p = 0.04). Due to lower nutritional reserves, smaller functional respiratory capacity, and more susceptibility to respiratory infections, younger children appear to have an increased vulnerability (15). The type of malnutrition also appeared to have an impact on oxygenation, as the prevalence of hypoxemia was higher in children with kwashiorkor (40.0%) compared to those with marasmus (29.1%). However, the difference was not statistically significant. This inclination can be explained by the fact that the likelihood of edema and difficulty with lagging pulmonary elasticity is higher in kwashiorkor, leading to an inability to exchange gases properly. The implications of these findings for the clinical environment are overwhelming (16). Hypoxemia is a defined independent risk factor for mortality in children admitted to the hospital, and its high prevalence in the present study should serve as a warning to monitor oxygenation throughout their hospitalization systematically. In most low-resource settings, such as Pakistan, pulse oximetry is not standard practice in nutritional rehabilitation units, and so, hypoxemia is underdiagnosed. Our findings show that clinical signs may not be an effective measure for detecting subtle hypoxemia and may not be evident until respiratory failure occurs (17). Routine SpO 2 measurement on admission and throughout the hospital stay may improve early identification and early oxygen therapy initiation, with the potential of decreasing mortality. This paper also emphasizes the need to combine the management of anemia with the management of malnutrition. As the concentration of hemoglobin has a direct effect on oxygen delivery, correcting anemia may be used to supplement oxygen therapy and achieve better outcomes. Although the present study will provide valuable insights, it has some limitations. The study is unique in that it boasts a relatively small sample size; it is also a single-center study, which may limit its generalizability, making it less likely that the findings will apply to a broader population. Resting oxygen saturation was measured only once at baseline and at the time of admission, without regular intervals or continuous monitoring, and follow-up values were not determined.

Conclusion

It is concluded that hypoxemia is a common and clinically significant finding in patients with severe malnutrition, with nearly one-third of children in this study demonstrating oxygen saturation below 90%. The presence of pneumonia and anemia was strongly associated with lower oxygen levels, while younger age and kwashiorkor also showed a greater tendency toward hypoxemia. These findings emphasize the importance of routine oxygen saturation monitoring in all malnourished patients at admission and during hospital stay, as clinical signs alone may be insufficient to detect early respiratory compromise.

Declarations

Data Availability statement
All data generated or analysed during the study are included in the manuscript.
Ethics approval and consent to participate
Approved by the department concerned. (IRBEC-24)
Consent for publication
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Not applicable

Conflict of interest

The authors declared the absence of a conflict of interest.

Author Contribution

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All authors reviewed the results and approved the final version of the manuscript. They are also accountable for the integrity of the study.

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