International Journal of Contemporary Pediatrics
Abiodun MT et al. Int J Contemp Pediatr. 2025 Aug;12(8):1289-1298
http://www.ijpediatrics.com
pISSN 2349-3283 | eISSN 2349-3291

DOI: https://dx.doi.org/10.18203/2349-3291.ijcp20252209

Original Research Article

Incidence, severity and outcomes of hypoxemia in paediatric emergencies seen at a tertiary hospital in Southern Nigeria

Moses T. Abiodun[1,2]*, Gabriel Oziegbe[3], Imuwahen A. Mbarie[4], Wilson O. Osarogiagbon[1,2], Collins E. Etin-Osa[5], Rosena O. Oluwafemi[6], Godwin E. Okungbowa[7], Ovonomo Ewhe[1], Rahmon Olusola[8], Benjamin Nandom[1], Adesuwa Kpongo-Ogieva[1], Jane Aghama[9], Cyril Oputa[5]

[1]Department of Child Health, University of Benin Teaching Hospital, Benin City, Nigeria
[2]School of Medicine, University of Benin, Benin City, Edo State, Nigeria
[3]Department of Paediatrics, State Specialist Hospital, Benin City, Nigeria
[4]Institute of Child Health, University of Benin City, Nigeria
[5]Department of Production Engineering, University of Benin City, Nigeria
[6]Department of Paediatrics and Child Health, University of Medical Sciences, Ondo State, Nigeria
[7]Department of Radiography, School of Basic Medical Sciences. University of Benin, Nigeria
[8]Department of Biomedical Engineering, University of Benin Teaching Hospital, Benin City, Nigeria
[9]Department of Physiotherapy, University of Benin, Nigeria

Received: 25 June 2025
Revised: 09 July 2025
Accepted: 11 July 2025

***Correspondence:**
Dr. Moses T. Abiodun,
E-mail: moses.abiodun@uniben.edu

ABSTRACT

Background: Hypoxemia refers to a low oxygen level in the blood, and is a significant morbidity in children. We evaluate the incidence, severity and outcome of hypoxemia as well as the prognostic usefulness of selected features in hypoxemic children.
Methods: This was an analytic, cross-sectional study. Participants were acutely-ill children. Data were collected on their demography, clinical features, pulse oximetry, diagnoses and outcomes. Descriptive and inferential analyses were done. Multiple logistic regression identified variables that independently predict hypoxemia and outcomes of the participants, using odds ratio (OR) and 95% confidence intervals (CI).
Results: Four hundred and seventy-six children participated in the study with a median (IQR) age of 2.0 (0.92–6.0) years; female: male ratio was 1:1. The incidence of hypoxemia was 59.2%; 96 (20.2%) were classified as mild, 62 (13.0%) as moderate and 124 (26.0%) as severe. Children aged 1–5 years were significantly more likely to have hypoxemia compared to those older than five years (OR=0.588, 95% CI: 0.358–0.964, p=0.035). Acute exacerbation of bronchial asthma showed a statistically significant association with hypoxemia severity (χ^2=13.616, p<0.001). A majority (89.9%) of the participants survived. The overall outcome of participants varied significantly based on SpO_2 levels (p=0.025). Severe hypoxemia was strongly linked to mortality (95% CI: 1.292–6.615, p=0.010).
Conclusions: Hypoxemia is common in childhood emergencies. Age of the affected child and nature of underlying disease as well as the severity of hypoxemia influence overall survival.

Keywords: Hypoxemia, Incidence, Severity, Outcomes, Paediatric emergencies

INTRODUCTION

Hypoxemia is a condition characterized by a reduced concentration of oxygen in arterial blood, limiting the amount available for aerobic respiration at the cellular level.[1] This blood oxygen level can be measured directly during blood gas analysis or using percutaneous oxygen saturation (SpO_2) levels in routine clinical practice.[2] The National Institutes of Health has defined a resting SpO_2 of ≤ 95% as abnormal, although it is frequently correlated with clinical symptoms to define severity, as there is no definitive cutoff value for tissue hypoxia.[3] Hypoxemia is also a common morbidity in acutely ill children.[4] In a multi-hospital survey in Rwanda, hypoxemia was seen in 18.6% to 22.8% of paediatric patients in the intensive care units.

Likewise, a recent systematic review and meta-analysis by Graham et al across 12 hospitals in Nigeria reported that about 25% of neonates and 12% of children admitted into emergency departments had hypoxemia, inclusive of both respiratory and non-respiratory conditions.[5] In Southwest Nigeria, Orimagunde et al found that the overall prevalence of hypoxemia was 28.6% irrespective of underlying etiologies, with the highest prevalence seen in acute lower respiratory tract infections in under-fives, and tetanus among neonates.[6] Besides ineffective pulmonary gaseous exchange, hypoxemia can also result from inefficient oxygen transport from the lungs due to sub-optimal hemoglobin levels predisposing to persistent hypoxemia or carbon monoxide competition.[7]

The severity of hypoxemia can be described as mild (SpO_2=90-94%), moderate (85-89%) and severe (<85%).[8] Severe hypoxemia often occurs in children with severe lower respiratory tract infections and cyanotic congenital heart disease.[9,10] Nonetheless, hypoxemia can rapidly progress if adequate supplemental oxygen is not provided irrespective of the patient's clinical diagnosis.[11] Graham et al reported a higher prevalence of hypoxemia in the neonatal age group related to their anatomic and physiologic peculiarities.[5]

Neonates have smaller airways and alveolar surfaces for gaseous exchange; also, prematurity with limited surfactant supply may worsen hypoxemia in this age group.[12] Significant neurologic dysfunction that can be associated with meningoencephalitis with raised intracranial pressure can sometimes predispose to severe hypoxemia.[13] Moreover, both intracardiac and extracardiac shunting that occurs in cyanotic congenital heart disease and persistent pulmonary hypertension can lead to severe refractory hypoxemia and tissue hypoxia with dire consequences.[14,15]

The outcomes of hypoxemic children can be favourable with prompt optimal oxygen supplementation or assisted ventilation. Duke et al in Papua New Guinea conducted a multi-hospital study which found that implementing low-flow oxygen in all children with hypoxemia and respiratory distress, even those without clinical symptoms, led to a reduction in hypoxemia-related mortality by 35% over 27 months.[16] Graham et al across five low-and-middle-income countries (LMICs) and King et al in Malawi found that severe hypoxemia was associated with paediatric mortality in their acute care setting, with mortality rates ranging from five-fold to over thirty-fold.[17,18]

Higher mortality rates were associated with lower oxygenation levels. Furthermore, a systematic review and meta-analysis done by Lazzerini et al on the effects of hypoxemia on mortality due to lower respiratory tract infection in 13 LMICs involving over 20,000 children found that hypoxemic children were five times more likely to die than those with normal oxygen levels.[10]

Considering that hypoxemia is readily detectable by point-of-care pulse oximetry and often treatable with low-flow nasal oxygen therapy, it is pertinent to investigate its burden in every paediatric practice. Moreover, in view of an ongoing project on high-flow nasal cannula oxygenation in our centre, we evaluate the incidence, severity and outcome of hypoxemia in acutely ill children in our emergency department. We hypothesized that modifiable factors contributed to the occurrence of hypoxemia. This study also explored the prognostic usefulness of selected clinical parameters in hypoxemia.

METHODS

Study design

This study adopted an analytic, cross-sectional design.

This study took place in the 40-bed children emergency rooms (CHERs) of the University of Benin Teaching Hospital (UBTH), in southern Nigeria. The CHER comprises a Casualty with Triage Area, a Ward and a Critical Care Bay. Portable pulse oximeter devices are in routine use in CHER. Multiparameter monitors, automated external defibrillator (AED), bubble CPAP device, Nasal High Flow Cannula (HFNC) device (Airvo2, Fisher & Paykel) and Siaree paediatric ventilators (Siaretron 2000 and Falco 202 EVO) are available in the critical care bay.

Participants

These were children who presented to the emergency room with acute illnesses and were admitted during the study period. Comorbid disorders in some of the participants have been previously described.[19]

Inclusion criteria

Children aged 1 month to 18 years with features of a critical or severe illness during the study period. A critical illness was defined as the presence of an acute

life-threatening disorder which requires an emergent or urgent intervention to prevent death.[19]

Exclusion criteria

Neonatal infants were not recruited into this study because they were directly admitted into a special care baby unit.

Sample size

The minimum sample size was determined using the formula for cross-sectional study.[20] $N=Z^1-\alpha\ 2-(P)\ (1-P)/d^2$; where, $Z^1-\alpha$ = normal standard deviation for confidence level of 95% = 1.96. P=Proportion of acutely-ill children with hypoxemia (we assumed 50%); d=margin of error to be tolerated (fixed at 5%).[20] This was adjusted for a 10% non-response rate. Altogether, 476 children were recruited during the study period.

Sampling method

This was a total population study of all eligible children admitted into CHER during the study period; they were consecutively recruited into the study following parental consent.

Data collection

Data were collected using a researcher-administered questionnaire comprising sections on baseline characteristics, pulse oximetry, diagnoses, treatments, clinical course and outcome. Also, review of clinical documentations on the participants was done to ascertain their response to oxygen supplementation and survival.

Statistical analysis

Descriptive and inferential analyses of the data were done using the IBM Statistical Package for Social Sciences (SPSS) version 26.0 for windows.

Categorical variables were described using frequencies and percentages while continuous variables such as age, duration of illness and SPO2 levels were described using means and standard deviation (SD) or median and interquartile range (IQR). The incidence of hypoxemia was derived from the proportion of affected participants. Bivariate analysis (Pearson chi-square) was done to detect any significant association between the descriptive variables and hypoxemia.

Variables that were significant on binary analysis were then subjected to multiple logistic regression to identify independent predictors of hypoxemia in the participants, using adjusted odds ratio (OR) and 95% confidence intervals (CI). $P<0.05$ was considered significant.

Ethical consideration

This research was done as a part of a large study evaluating the critical care of paediatric emergencies at the centre. Ethical clearance for the study was obtained from the Health Research Ethics Committee (HREC) of the University of Benin Teaching Hospital. Informed consent was obtained from the parents/caregivers of the children.

RESULTS

Baseline characteristics of the participants (N=476)

The study comprised 476 participants with a median (IQR) age of 2.0 (0.92–6.0) years. The majority, 210 (44.1%), were between one and five years old, while 145 (30.5%) were less than one-year old, and 121 (25.4%) were older than five years.

There was a near-equal gender distribution, with 249 (52.3%) males and 227 (47.7%) females. Ethnic distribution showed that 197 (41.4%) participants were Benin, while 51 (10.7%) were Igbo, 21 (4.4%) were Yoruba, and 5 (1.1%) were Hausa.

Socioeconomic classification indicated that 299 (62.8%) of the participants were in the middle class, 141 (29.6%) in the upper class, and 36 (7.6%) in the lower class. Most patients, 403 (84.7%), were brought from home, whereas 40 (8.4%) presented from private hospitals, and 33 (6.9%) were referred from public health facilities. The median (IQR) duration of hospital stay was 2.0 (4.0–7.0) days. Further details are shown on Table 1.

Table 1: Baseline characteristics of participants at presentation.

Characteristics	Frequency (N)	%
Age (in years)		
<1	145	30.5
1-5	210	44.1
>5	121	25.4
Median (IQR)	2.0 (0.92 –6.0)	
Gender		
Male	249	52.3
Female	227	47.7
Ethnicity		

Continued.

Characteristics	Frequency (N)	%
Benin	19	41.4
Igbo	51	10.7
Yoruba	21	4.4
Hausa	5	1.1
Others	202	42.4
Maternal level of education		
None	21	4.4
Primary	72	15.1
Secondary	113	23.7
Tertiary	270	56.7
Socioeconomic status		
Upper	141	29.6
Middle	299	62.8
Lower	36	7.6
Religion		
Christianity	470	98.7
Others	6	1.3
Source of patient		
Private	40	8.4
Public	33	6.9
Home	403	84.7
Median (IQR) duration of stay (days)	2.0 (4.0–7.0)	

Table 2: Clinical diagnosis among the participants (n=476).

Clinical diagnosis*	Frequency (N)	%
Severe malaria	116	24.4
Tonsillitis**	191	40.1
Pneumonia	85	17.9
Sickle cell crisis	38	8.0
Upper respiratory tract infection	30	6.3
Dehydration	39	8.2
Acute watery diarrhea	38	8.0
Heart failure	27	5.7
Epilepsy	24	5.0
Urinary tract infections	17	3.6
Tuberculosis	15	3.2
Asthma	14	2.9
Meningitis	8	1.7
Appendicitis	8	1.7
Malnutrition	6	1.3
Bronchiolitis	6	1.3
Acute kidney injury	3	0.7

*Multiple diagnoses present in some children; **CHER admission due to persistent vomiting or poor oral intake; a common comorbid diagnosis.

Table 3: Incidence and severity of hypoxemia among the participants (n=476).

Variables	Frequency (n=476)	%)
SpO_2 levels		
≥95	194	40.8
<95	282	59.2
Median (IQR)	92.0 (82.5 – 98.0)	
Severity of hypoxemia		
Mild (90-94)	96	20.2
Moderate (85-89)	62	13.0
Severe (<85)	124	26.0

Table 4: Factors associated with severity of hypoxemia among the participants.

Variables	SpO_2 level			χ^2	P value
	Severe (n=124) N (%)	Moderate (n=62) N (%)	Mild (n=96) N (%)		
Age group (in years)					
<1	42 (46.7)	22 (24.4)	26 (28.9)	2.342	0.677
1-5	59 (44.7)	27 (20.5)	46 (34.8)		
>5	23 (38.3)	13 (21.7)	24 (40.0)		
Gender					
Male	68 (47.6)	28 (19.6)	47 (32.9)	1.727	0.422
Female	56 (40.3)	34 (24.5)	49 (35.3)		
Socioeconomic status					
Upper	24 (30.8)	18 (23.1)	36 (46.2)	13.391	0.037*
Middle	92 (49.2)	41 (21.9)	54 (28.9)		
Lower	8 (47.1)	3 (17.6)	6 (35.3)		

*Statistically significant

Table 5: Severity of hypoxemia by clinical diagnosis among the participants.

Clinical diagnosis	SpO_2 level			χ^2	P value
	Severe (n=124) N (%)	Moderate (n=62) N (%)	Mild (n=96)		
Malaria					
Yes	26 (34.7)	17 (22.7)	32 (42.7)	4.266	0.122
No	98 (46.9)	45 (21.5)	64 (30.6)		
Tonsillitis					
Yes	46 (39.7)	18 (15.5)	52 (44.8)	11.319	0.003*
No	78 (47.0)	44 (26.5)	44 (26.5)		
Pneumonia					
Yes	27 (49.1)	11 (20.0)	17 (30.9)	0.727	0.703
No	97 (42.7)	51 (22.5)	79 (34.8)		
Sickle cell					
Yes	7 (50.0)	3 (21.4)	4 (28.6)	0.295	0.938
No	117 (43.7)	59 (22.0)	92 (34.3)		
Upper respiratory tract infection					
Yes	6 (35.3)	5 (29.4)	6 (35.3)	0.772	0.689
No	118 (44.5)	57 (21.5)	90 (34.0)		
Heart failure					
Yes	10 (55.6)	3 (16.7)	5 (27.7)	1.056	0.636
No	114 (43.2)	59 (22.3)	91 (34.5)		
Dehydration					
Yes	10 (41.7)	4 (16.7)	10 (41.7)	0.817	0.703
No	114 (44.2)	58 (22.5)	86 (33.3)		
Asthma					
Yes	11 (100.0)	0 (0.0)	0 (0.0)	13.616	<0.001*
No	113 (41.7)	62 (22.9)	96 (35.4)		

*Statistically significant

Table 6: Multiple logistic regression for independent predictors of hypoxemia among participants.

Variables	Hypoxemia, SpO_2 <95%, N (%)	OR	95% CI		P value
			Lower	Upper	
Age (in years)					
<1	90 (31.9)	0.585	0.342	1.001	0.051
1-5	132 (46.8)	0.588	0.358	0.964	0.035
>5*	60 (21.3)	1			

Continued.

Variables	Hypoxemia, SpO_2 <95%, N (%)	OR	95% CI		P value
			Lower	Upper	
Duration of illness					
<5 days	214 (75.9)	0.977	0.503	1.898	0.945
5-7 days	40 (14.2)	1.614	0.730	3.566	0.237
>7 days*	28 (9.9)	1			
Clinical diagnosis					
Tonsillitis	119 (42.2)	0.838	0.551	1.276	0.410
Severe malaria	76 (27.0)	0.650	0.406	1.039	0.650
Pneumonia	53 (18.8)	0.807	0.479	1.360	0.421
Heart failure	19 (6.7)	0.453	0.184	1.111	0.084
Seizures	19 (6.7)	0.288	0.102	0.810	0.018**
Sickle cell	14 (5.0)	2.106	1.014	4.373	0.046**
Asthma	8 (2.8)	1.046	0.343	3.189	0.937

*Reference category, ** Statistically significant; OR = Odd ratio

Table 7: Overall outcomes of participants with or without hypoxemia.

SpO_2 levels	Overall outcome				Fisher's Exact	P value
	Discharged (n=269) N (%)	Dead (n=48) N (%)	LAMA (n=4) N (%)	Transferred (n=155) N (%)		
Severe	60 (48.4)	17 (13.7)	0 (0.0)	47 (37.9)	18.726	0.025*
Moderate	37 (59.7)	11 (17.7)	0 (0.0)	14 (22.6)		
Mild	59 (61.5)	10 (10.4)	1 (1.0)	26 (27.1)		
Normal	113 (58.2)	10 (5.2)	3 (1.5)	68 (35.1)		

*Statistically significant; LAMA = left against medical advice

Table 8: Adjusted residuals for relationship between SPO2 and Overall outcome of respondents.

SpO_2 levels	Discharged	Dead	LAMA	Transferred
Severe	-2.1	1.6	-1.2	1.5
Moderate	0.5	2.1	-0.8	-1.8
Mild	1.1	0.1	0.2	-1.3
Normal	0.6	-3.0	1.4	1.0

LAMA = left against medical advice

Table 9: Relationship between hypoxemia and paediatric mortality.

Hypoxemia	Frequency n=282 (%)	β co-efficient	95% CI		P value
			Lower	Upper	
Severe	124 (26.0)	2.923	1.292	6.615	0.010**
Moderate	62 (13.0)	3.969	1.596	9.867	0.003**
Mild	96 (20.2)	2.140	0.859	5.332	0.103
Normal*		1			

*Reference category, ** Statistically significant

Clinical diagnosis and differentials

The most common clinical diagnosis among the 476 participants was tonsillitis, affecting 191 (40.1%) often as a comorbidity. Severe malaria was diagnosed in 116 (24.4%), followed by pneumonia in 85 (17.9%) and sickle cell crisis in 38 (8.0%). Other notable diagnoses included heart failure in 27 (5.7%), epilepsy in 24 (5.0%), urinary tract infections in 17 (3.6%), tuberculosis in 15 (3.2%), asthma in 14 (2.9%). and bronchiolitis 6 (1.3%). Acute kidney injury was the least frequent diagnosis, identified in 3 (0.7%) as shown on Table 2. Among the 116 cases of severe malaria, cerebral malaria was the most common severity criterion, affecting 48 (41.4%). Severe anemia was observed in 42 (36.2%), while multiple convulsions occurred in 33 (28.4%). Prostration was reported in 24 (20.7%), and persistent vomiting in 21 (18.1%). Hemoglobinuria and shock were each recorded in 3 (2.6%) cases, while acute kidney injury was present in 2 (1.7%).

Incidence and severity of hypoxemia

Table 3 shows that 282 (59.2%) participants had oxygen saturation (SpO_2) levels below 95%, while 194 (40.8%) maintained levels of 95% or higher. Among those with

hypoxemia (SpO_2 <95%), the severity varied, with 96 (20.2%) classified as mild (SpO_2 90–94%), 62 (13.0%) as moderate (SpO_2 85–89%), and 124 (26.0%) as severe (SpO_2 <85%).

Factors associated with severity of hypoxemia

Socioeconomic status had a statistically significant association with the severity of hypoxemia as shown on Table 4 (χ^2=13.391, p=0.037). Among those in the upper socioeconomic class, 24 (30.8%) had severe hypoxemia, 18 (23.1%) had moderate hypoxemia, and 36 (46.2%) had mild hypoxemia. In the middle class, 92 (49.2%) had severe hypoxemia, 41 (21.9%) had moderate hypoxemia, and 54 (28.9%) had mild hypoxemia. Among those in the lower class, 8 (47.1%) had severe hypoxemia, 3 (17.6%) had moderate hypoxemia, and 6 (35.3%) had mild hypoxemia. Based on adjusted residual analysis for relationship between SpO_2 and socioeconomic status, participants in the upper socioeconomic class had a negative association with severe hypoxemia (-2.8) and a positive association with mild hypoxemia (2.7), suggesting a lower likelihood of severe hypoxemia in this group.

In contrast, those in the middle class had a positive association with severe hypoxemia (2.5) and a negative association with mild hypoxemia (-2.6), indicating a higher likelihood of severe hypoxemia. The lower socioeconomic class showed only a slight positive association with severe hypoxemia (0.3). These findings suggest that individuals in the upper socioeconomic class are less likely to experience severe hypoxemia, whereas those in the middle class have a relatively higher risk. The relationship between age group and severity of hypoxemia was not statistically significant (χ^2=2.342, p=0.677). Also, gender was also not significantly associated with hypoxemia severity (χ^2=1.727, p=0.422).

Severity of hypoxemia by clinical diagnosis

Asthma showed a statistically significant association with hypoxemia severity (χ^2=13.616, p<0.001). All 11 (100.0%) participants with asthma had severe hypoxemia, with none classified under moderate or mild hypoxemia. Among those without asthma, 113 (41.7%) had severe hypoxemia, 62 (22.9%) had moderate hypoxemia, and 96 (35.4%) had mild hypoxemia. This suggests that asthma was strongly associated with an increased likelihood of severe hypoxemia. Also, tonsillitis showed a statistically significant association with hypoxemia severity (χ^2=11.319, p=0.003).

Among participants diagnosed with tonsillitis, 46 (39.7%) had severe hypoxemia, 18 (15.5%) had moderate hypoxemia, and 52 (44.8%) had mild hypoxemia. In contrast, among those without tonsillitis, 78 (47.0%) had severe hypoxemia, 44 (26.5%) had moderate hypoxemia, and 44 (26.5%) had mild hypoxemia. Pneumonia was not significantly associated with SpO_2 levels (χ^2=0.727, p=0.703). Among those with pneumonia, 27 (49.1%) had severe hypoxemia, 11 (20.0%) had moderate hypoxemia, and 17 (30.9%) had mild hypoxemia. Among those without pneumonia, 97 (42.7%) had severe hypoxemia, 51 (22.5%) had moderate hypoxemia, and 79 (34.8%) had mild hypoxemia. The presence of malaria was not significantly associated with hypoxemia severity as shown on Table 5 (χ^2=4.266, p=0.122).

Independent predictors of hypoxemia

The logistic regression analysis for factors associated with hypoxemia (SpO_2<95%) revealed that age and certain clinical diagnoses significantly influenced its occurrence (Table 6). Infants younger than one year had a borderline significant association with hypoxemia (OR=0.585, 95% CI: 0.342–1.001, p=0.051), while children aged 1–5 years were significantly more likely to have hypoxemia compared to those older than five years (OR = 0.588, 95% CI: 0.358–0.964, p=0.035).

The source of referral and duration of illness did not show a statistically significant association with hypoxemia. Sickle cell disease showed a significant positive association with hypoxemia (OR=2.106, 95% CI: 1.014–4.373, p=0.046). Also, epilepsy was significantly associated with hypoxemia (OR=0.288, 95% CI: 0.102–0.810, p=0.018), Other conditions, including severe malaria, pneumonia, dehydration, diarrhoea, heart failure, and upper respiratory tract infections, did not demonstrate significant associations with hypoxemia.

Outcomes of participants with or without hypoxemia

The relationship between SPO_2 levels and early outcomes within the first 24 hours was not statistically significant (Fisher's exact test = 8.366, p=0.190) but the overall outcome of participants varied significantly based on SPO_2 levels (Fisher's exact test=18.726, p=0.025). Among participants with severe hypoxemia, 60 (48.4%) were discharged, 17 (13.7%) died, none left against medical advice, and 47 (37.9%) were transferred. In the moderate hypoxemia group, 37 (59.7%) were discharged and 11 (17.7%) died. Participants with mild hypoxemia had better outcomes, with 59 (61.5%) discharged, 10 (10.4%) deceased.

Among those with normal SpO_2 levels, 113 (58.2%) were discharged, 10 (5.2%) died, 3 (1.5%) left against medical advice, and 68 (35.1%) were transferred as shown on Table 7a. On post-hoc analysis, the adjusted residuals for the relationship between SpO_2 levels and overall outcomes indicate varying trends across different categories, Table 7.

Severe hypoxemia was associated with a lower likelihood of discharge (-2.1). Moderate hypoxemia was strongly associated with death (2.1). Normal SpO_2 levels were linked to a lower likelihood of death (-3.0) and an increased probability of discharge (0.6) and leaving

against medical advice (1.4). These findings reinforce that severe and moderate hypoxemia were strongly linked to poorer outcomes, particularly increased mortality, whereas normal SpO_2 levels were more associated with favorable outcomes.

Hypoxemia and paediatric mortality

Severe hypoxemia was strongly linked to higher mortality, with a β coefficient of 2.923 (95% CI: 1.292–6.615, p=0.010), indicating that children with severe hypoxemia had nearly three times the odds of mortality compared to those with normal SpO_2 levels (Table 8). Moderate hypoxemia was associated with an even higher risk, with a β coefficient of 3.969 (95% CI: 1.596–9.867, p=0.003), suggesting nearly four times the likelihood of mortality. Mild hypoxemia had no significant impact on survival of the participants (p=0.103).

DISCUSSION

This study revealed a high incidence of hypoxemia among acutely-ill children in the emergency room (CHER), comparable to prior reports by Kuti et al in Osun and Orimagunde et al in Ibadan that about one third of paediatric emergencies are associated with hypoxemia.[6,21] Our finding is also consistent with the recent report of high burden of paediatric hypoxemia of over one-fifth of cases across secondary health facilities in south-west Nigeria by Graham et al.[17] Furthermore, researchers in other climes have found that low blood oxygen levels are common in childhood disorders including non-respiratory illnesses.[22,23]

Although mild hypoxemia was the commonest type in this study, at least three out of every ten participants had moderate or severe hypoxemia, corroborating systematic reviews and meta-analyses by Subhi et al and Rahman et al over several continents, that severe hypoxemia is common in critically-ill children.[23,25] Young children especially neonates are susceptible to hypoxemia partly due to their small residual lung capacity and smaller dimensions of their airways, making them prone to obstruction hence, preschool children were more likely to be hypoxic in this study compared to older children.[25]

However, age was not a major determinant of the severity of hypoxemia in the participants perhaps due to our exclusion of neonatal infants from this study. Socio-economic status influenced the severity of hypoxemia in our participants, possibly influencing the promptness of presentation of the children at the health facility, allowing the pathologies to worsen, as reported by Simbila et al in Tanzania.[26]

Primary respiratory illnesses including bronchial asthma were significantly associated with severe hypoxemia in this study, identical to previous research findings.[4,22] Sickle cell anaemia with acute chest syndrome was identified as an independent predictor of the occurrence of hypoxemia among our participants, consistent with the underlying vaso-occlusive pathophysiologic mechanisms of the disorder.[27,28] Acute neurologic disorders can be associated with impaired ventilation with resultant hypoxemia in children observed in the index study but prompt resuscitative measures often restore normal oxygen saturation in affected children.[29]

A majority of our participants improved or stabilized in the first twenty hours on admission, reflecting the availability of optimal resuscitative measures at the paediatric emergency department. However, subsequent deterioration was more likely to occur in children with severe hypoxemia early on admission; this is apparently a reflection of the deficient paediatric critical care capacity in the locale as highlighted by Eki-Udoko et al and Imarangiaye et al.[30,31] Similarly, Akindolire et al opined that the unmet need of paediatric critical care services in developing settings undermine the survival of acute-ill children.[32]

Furthermore, nearly one-fifth of children with severe hypoxemia died while on admission confirming the significant multi-systemic effects of persistent hypoxemia.[33,34] Özel et al in Turkey found that hypoxemia and elevated serum lactate levels were associated with mortality of children in their emergency department.[35] Duration of illness and sources of referral did not independently influence the clinical course of the participants at the tertiary centre.

Paediatric mortality is significantly influenced by hypoxemia in our study evidenced by the increased odds of death children with both moderate and severe hypoxemia similar to prior studies.[10,18] Graham et al found that the case fatality rate of several paediatric disorders increased with concurrent hypoxemia. In addition, systematic reviews with metanalyses on the prognostic value of hypoxemia in children reported increased relative risk of death in children and neonates with hypoxemia in sub-Saharan Africa and beyond.[5,10,23] Other determinants of mortality in the literature include the severity and nature of the underlying illness.

This has been shown by incorporating SpO_2 levels into severity of illness scores to predict the survival of acutely-ill children. Temessadouno et al showed that Paediatric Early Warning System (PEWS) scores greater than 6 on admission or a PEWS score greater than 4 after 24 hours on admission is associated with a six-fold higher risk of clinical deterioration and death.[36] The paediatric index of mortality (PIM) scoring also comprises partial pressure of blood oxygen. levels and predicts mortality in children.[39] This emphasizes the need to ensure optimal oxygen saturation in emergency childhood disorders.

The strength of this study includes the large sample size ensuring that the research is adequately powered to detect the occurrence of hypoxemia in various paediatric emergencies. This also enhances the generalizability of

the findings. In addition, both the early and overall outcomes of the participants were documented enabling the evaluation of the prognostic utility of SPO_2 measured in childhood disorders. Nonetheless, the levels of respiratory supports provided to the participants were not explored. Children who showed poor response to conventional intranasal oxygen and were escalated to high flow nasal canula oxygen (HFNC) therapy or continuous positive airway pressure (CPAP) therapy were not sub-analyzed due to incomplete data. Prior studies by Abiodun et al and Bjorklund et al on non-invasive respiratory supports including HFNC have showcased the efficacy of these interventions.[38,39] Also, outcome of some participants who were transferred to the intensive care unit were not documented in this index study.

CONCLUSION

In conclusion, hypoxemia is common in childhood emergencies. Age of the affected child and nature of underlying disease as well as the severity of hypoxemia influence overall survival. Prompt detection of hypoxemia and provision of supplemental oxygen is pertinent in children with both respiratory and non-respiratory acute illnesses.

ACKNOWLEDGEMENTS

The Research Group would also like to extend our gratitude to the University of Benin Teaching Hospital, Benin City, and the University of Medical Sciences Teaching Hospital, Ondo City, Nigeria for their support in this collaborative project.

Funding: The authors gratefully acknowledge the financial support provided by the Tertiary Education Trust Fund (TETFund) and the National Research Fund (NRF) under grant number NRF2023/SETI/III/00572/VOL.1.
Conflict of interest: None declared
Ethical approval: The study was approved by the Institutional Ethics Committee was obtained from the Health Research Ethics Committee (HREC) of the University of Benin Teaching Hospital (Protocol Number: ADM/E 22/A/VOL. VII/48311701).

REFERENCES

1. Sarkar M, Niranjan N, Banyal P. Mechanisms of hypoxemia. Lung India. 2017;34(1):47.
2. Rauniyar N, Pujari S, Shrestha P. Study of oxygen saturation by pulse oximetry and arterial blood gas in ICU patients: a descriptive cross-sectional study. J Nepal Med Association. 2020;58(230):5536.
3. Bhutta BS, Alghoula F, Berim I. Hypoxia. StatPearls. Available at: www.ncbi.nlm.nih.gov. Accessed 8th March 2025.
4. Graham H, Bakare AA, Ayede AI. Hypoxaemia in hospitalised children and neonates: A prospective cohort study in Nigerian secondary-level hospitals. E Clin Med. 2019;16:51-63.
5. Graham HR, Jahan E, Subhi R. The prevalence of hypoxaemia in paediatric and adult patients in health-care facilities in low-income and middle-income countries: a systematic review and meta-analysis. Lancet Glob Health. 2025;13(2):222-31.
6. Orimadegun AE, Ogunbosi BO, Carson SS. Prevalence and predictors of hypoxaemia in respiratory and non-respiratory primary diagnoses among emergently ill children at a tertiary hospital in south western Nigeria. Trans R Soc Trop Med Hyg. 2013;107(11):699-705.
7. ATS/ACCP statement on cardiopulmonary exercise testing. Am J Respir Crit Care Med. 2003;167(2):211-277.
8. Oxygenation and Oximetry–International Emergency Medicine Education Project. Available at: https://iem-student.org/2020/10/05/oxygenation-and-oximetry. Accessed on 8 March 2025.
9. Araujo J. Chronic Hypoxemic Syndrome and Congenital Heart Disease in Adults: A Multisystemic Disorder. J Cardiol Cardiovasc Ther. 2018;10(4):60-7.
10. Lazzerini M, Sonego M, Pellegrin MC. Hypoxaemia as a mortality risk factor in acute lower respiratory infections in children in low and middle-income countries: systematic review and meta-analysis. PLoS One. 2015;10(9):136166.
11. Thille AW, Balen F, Carteaux G. Oxygen therapy and noninvasive respiratory supports in acute hypoxemic respiratory failure: a narrative review. Ann Intensive Care. 2024;14(1):158.
12. Saikia D, Mahanta B. Cardiovascular and respiratory physiology in children. Indian J Anaesth. 2019;63(9):690.
13. Glimåker M, Johansson B, Halldorsdottir H. Neuro-intensive treatment targeting intracranial hypertension improves outcome in severe bacterial meningitis: an intervention-control study. PLoS One. 2014;9(3):91976.
14. Stark R, Shekerdemian L. Estimating intracardiac and extracardiac shunting in the setting of complex congenital heart disease. Ann Pediatr Cardiol. 2013;6(2):145.
15. Lakshminrusimha S, Keszler M. Persistent Pulmonary Hypertension of the Newborn. Neoreviews. 2015;16(12):680-92.
16. Duke T, Wandi F, Jonathan M. Improved oxygen systems for childhood pneumonia: a multihospital effectiveness study in Papua New Guinea. Lancet. 2008;372(9646):1328-33.
17. Graham HR, King C, Duke T. Hypoxaemia and risk of death among children: rethinking oxygen saturation, risk-stratification, and the role of pulse oximetry in primary care. Lancet Glob Health. 2024;12(8):1359-64.
18. King C, Zadutsa B, Banda L. Prospective cohort study of referred Malawian children and their

survival by hypoxaemia and hypoglycaemia status. Bull World Health Organ. 2022;100(05):302-14.
19. Abiodun MT, Iduoriyekemwen NJ, Enato IG. Evaluation of dyselectrolytemia in acutely-ill children seen in the emergency room of a referral hospital in southern Nigeria. Nigerian J Clin Pract. 2023;26(5):649-50.
20. Charan J, Biswas T. How to calculate sample size for different study designs in medical research. Indian J Psychol Med. 2013;35(2):121-6.
21. Kuti BP, Adetola HH, Aladekomo TA, Kuti DK. Prevalence and predictors of hypoxaemia in hospitalised children at the emergency unit of a resource constrained cen. Niger J Paediatr. 2016;43(4):273.
22. Tamene DG, Toni AT, Ali MS. Hypoxemia and its clinical predictors among children with respiratory distress admitted to the University of Gondar Comprehensive Specialized Hospital, Northwest Ethiopia. BMC Pediatr. 2024;24(1):416.
23. Rahman AE, Hossain AT, Nair H. Prevalence of hypoxaemia in children with pneumonia in low-income and middle-income countries: a systematic review and meta-analysis. Lancet Glob Health. 2022;10(3):348-59.
24. Subhi R, Adamson M, Campbell H, Weber M, Smith K, Duke T. The prevalence of hypoxaemia among ill children in developing countries: a systematic review. Lancet Infect Dis. 2009;9(4):219-27.
25. Trachsel D, Erb TO, Hammer J, von Ungern-Sternberg BS. Developmental respiratory physiology. Pediatric Anesthesia. 2022;32(2):108-17.
26. Simbila AN, Kilindimo SS, Sawe HR. Predictors and outcome of time to presentation among critically ill paediatric patients at Emergency Department of Muhimbili National Hospital, Dar es Salaam, Tanzania. BMC Pediatr. 2022;22(1):441.
27. Noronha SA. Cardiac causes of hypoxia in sickle cell disease. Prog Pediatr Cardiol. 2020;56:101192.
28. Khan MI, Patel N, Meda RT, Nuguru SP, Rachakonda S, Sripathi S. Sickle cell disease and its respiratory complications. Cureus. 2022;10:28528
29. Al-Beltagi M, Saeed NK, Bediwy AS, Elbeltagi R. Pulse oximetry in pediatric care: Balancing advantages and limitations. World J Clin Pediatr. 2024;13(3):875.
30. Eki-Udoko FE, Ani C, Osagie EG, Atimati AO. Paediatric emergency admissions, mortalities, and unmet intensive care needs at a tertiary hospital in Southern Nigeria. Niger J Paediatr. 2024;51(2):73-82.
31. Abiodun M, Imarengiaye C. Clinical-demographic profile, critical care and outcome of children admitted into a level III intensive care unit in southern Nigeria. Ann Clin Biomed Res. 2025;6(1):513.
32. Akindolire AE, Tongo OO. Paediatric critical care needs assessment in a tertiary facility in a developing country. Niger J Paediatr. 2018;45(1):10.
33. Systemic hypoxia drives inflammation persistence via suppression of monocytes. Nat Immunol. 2022;23(6):830-1.
34. Chen PS, Chiu WT, Hsu PL. Pathophysiological implications of hypoxia in human diseases. J Biomed Sci. 2020;27(1):63.
35. Özel A, İlbeği EN, Yüce S. Predictive value of initial lactate levels for mortality and morbidity in critically ill pediatric trauma patients: a retrospective study from a Turkish pediatric intensive care unit. Acute Crit Care. 2025;40(1):87-94.
36. Temessadouno FW. Evaluation of a paediatric early warning system (PEWS) score on admission to a paediatric intensive care unit to predict mortality risk in a low resource setting, Guinea-Bissau. Community Med Publ Heal Care. 2023;10(1):1-6.
37. Shann F, Pearson G, Slater A, Wilkinson K. Paediatric index of mortality (PIM): a mortality prediction model for children in intensive care. Intensive Care Med. 1997;23(2):201-7.
38. Abiodun MT, Enato IG. Heated Humidified High Flow Nasal Cannula for Non-Invasive Primary Respiratory Support in Neonates: Experience of a Referral Neonatal Level III Facility in South-South Nigeria. Cognizance J Multidiscipl Stud. 2024;4(8):184-97.
39. Bjorklund AR, Odongkara Mpora B, Steiner ME, Fischer G, Davey CS, Slusher TM. Use of a modified bubble continuous positive airway pressure (bCPAP) device for children in respiratory distress in low- and middle-income countries: a safety study. Paediatr Int Child Health. 2019;39(3):160-7.

Cite this article as: Abiodun MT, Oziegbe G, Mbarie IA, Osarogiagbon WO, Etin-Osa CE, Oluwafemi RO, et al. Incidence, severity and outcomes of hypoxemia in paediatric emergencies seen at a tertiary hospital in Southern Nigeria. Int J Contemp Pediatr 2025;12:1289-98.