(RESEARCH ARTICLE)

Risk Factors for Community-Acquired Pneumonia in Children with Severe Acute Malnutrition in N'Djamena, Chad

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Abstract

Background: Community-acquired pneumonia remains a leading cause of child mortality in sub-Saharan Africa. Severe acute malnutrition (SAM) increases susceptibility to respiratory infections and worsens clinical outcomes. In Chad, evidence on pneumonia risk factors among malnourished children is scarce. This study aimed to identify factors associated with community-acquired pneumonia in children with SAM in N'Djamena.

Methods: We conducted an analytical case–control study from 1 January to 31 December 2024 at the Chad–China Friendship Hospital. Eligible participants were children aged 6–59 months with SAM. Cases were children with SAM and community-acquired pneumonia diagnosed using World Health Organization (WHO) criteria. Controls were children with SAM without pneumonia, hospitalized during the same period. Socio-demographic, nutritional, environmental, and clinical data were extracted from medical records. Multivariable logistic regression identified independent risk factors.

Results: A total of 246 children with SAM were included: 108 cases (44.0%) and 138 controls (56.0%). The median age was 18 months (interquartile range [IQR] 10–32); 53.2% were male. Independent predictors of pneumonia were incomplete vaccination (adjusted odds ratio [aOR] 2.41; 95% CI 1.34–4.35), exposure to biomass smoke (aOR 3.87; 95% CI 1.72–8.73), household overcrowding (aOR 2.15; 95% CI 1.18–3.93), delay in seeking care ≥3 days (aOR 2.64; 95% CI 1.39–5.00), MUAC <110 mm (aOR 1.98; 95% CI 1.06–3.69), and malaria co-infection (aOR 1.87; 95% CI 1.01–3.45).

Conclusion: Among children with SAM, pneumonia is strongly associated with modifiable and preventable factors. Strengthening routine immunization, reducing household air pollution, addressing overcrowding, promoting timely care-seeking, and integrating nutritional support with infection management are essential to reduce pneumonia-related morbidity and mortality.

Keywords: Pneumonia; Severe acute malnutrition; Risk factors; Children; Chad

1. Introduction

Community-acquired pneumonia remains a major contributor to child mortality in sub-Saharan Africa. Recent analyses show its continued impact among children under five years and an increasing burden among those aged 5–9 years [1]. Severe acute malnutrition (SAM), highly prevalent across the Sahel region, substantially increases susceptibility to respiratory infections and worsens disease prognosis. Reducing undernutrition is therefore recognized as a cornerstone of strategies to prevent childhood mortality [2,3].

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Multiple reviews have demonstrated that SAM, along with hypoxemia and altered consciousness, is among the strongest predictors of mortality in children with pneumonia in low- and middle-income countries [4]. In addition, studies from West and Central Africa have identified important environmental and socioeconomic determinants of respiratory infections, such as household overcrowding, poverty, use of unclean cooking fuels, and inadequate sanitation [5].

Despite a growing regional evidence base, investigations specifically focusing on pneumonia among children with SAM in Chad remain very limited. Research from East Africa has reported a high prevalence of pneumonia in malnourished children and has identified risk factors relevant for clinical management and prevention [6]. Generating local data is essential to inform context-specific clinical guidelines and public health strategies [1–3].

This study aimed to identify sociodemographic, nutritional, environmental, and clinical factors associated with community-acquired pneumonia among children with SAM hospitalized in a tertiary facility in N'Djamena.

2. Patients and Methods

2.1. Study setting

The study was conducted at the Chad–China Friendship Hospital (Hôpital de l'Amitié Tchad–Chine, HATC), a major referral institution in N'Djamena with approximately 500 beds. The hospital includes general pediatrics, a therapeutic nutrition unit (UNT), radiology services (including X-ray, ultrasound, and CT), and a medical laboratory offering standard diagnostic tests. The UNT manages children with SAM according to national guidelines and WHO recommendations.

2.2. Study Design and Period

We conducted an analytical case–control study from 1 January to 31 December 2024 among children aged 6–59 months admitted to the pediatric department or the UNT.

2.3. Eligibility Criteria

Cases were children who met all of the following criteria:

- Severe acute malnutrition (weight-for-height <–3 z-scores, MUAC <115 mm, and/or nutritional edema)
- Community-acquired pneumonia diagnosed using WHO criteria (cough and/or respiratory distress with age-specific tachypnea, with or without radiographic confirmation)

Controls were children with SAM who:

- Had no clinical or radiological signs of pneumonia
- Were hospitalized in the same units during the same period

Exclusion criteria: nosocomial pneumonia (onset ≥48 hours after admission), major congenital anomalies, or severe congenital heart disease.

2.4. Data Collection

Data were collected using a standardized form from medical records, admission logs, and nutritional follow-up sheets. Variables included:

- Sociodemographic: age, sex, residence
- Nutritional: type of malnutrition, MUAC, oedema
- Vaccination: complete vs incomplete routine immunisation
- Health care access: delay before first consultation (<3 vs ≥3 days)
- Environmental: biomass smoke exposure, passive smoking, overcrowding, cooking area
- Clinical and infectious: HIV status, confirmed malaria, respiratory signs, oxygen saturation

2.5. Statistical Analysis

Data analysis was performed using STATA version 14. Quantitative variables were reported as mean ± SD or median (IQR), and categorical variables as frequencies and percentages. Chi-square or Fisher's exact tests were used for categorical variables, and t-tests or Mann–Whitney U tests for continuous variables.

Variables with p <0.20 in univariate analysis were included in a multivariable logistic regression model. Adjusted odds ratios (aOR) with 95% confidence intervals (CI) were calculated. Statistical significance was set at p <0.05.

2.6. Ethical Considerations

The study protocol was approved by the HATC Ethics Committee. Confidentiality was ensured, and no additional costs were incurred by participating families.

3. Results

3.1. General characteristics of the population

A total of 246 children with SAM aged 6–59 months were included: 108 cases (44.0%) and 138 controls (56.0%). The median age was 18 months (IQR 10–32), with no significant difference between groups (p = 0.21). Boys accounted for 55.3% of cases and 51.4% of controls (p = 0.48).

Most children (73.9%) lived in peripheral, socioeconomically disadvantaged neighbourhoods, and 81.7% resided in households using biomass fuels for cooking.

3.2. Nutritional and clinical characteristics

Table 1 summarises the main sociodemographic and nutritional characteristics of the children.

Table 1 Sociodemographic and nutritional characteristics of children with SAM included in the study

Variables	Cases (n = 108)	Controls (n = 138)	p value
Median age (months), IQR	18 (10–32)	19 (11–30)	0.21
Male sex, n (%)	60 (55.3)	71 (51.4)	0.48
Type of malnutrition, n (%)			
• Marasmus	78 (72.2)	88 (63.8)	0.18
• Kwashiorkor	19 (17.6)	37 (26.8)	0.04*
• Mixed	11 (10.2)	13 (9.4)	0.82
MUAC (mm), mean ± SD	108.2 ± 6.3	112.5 ± 5.9	<0.001*
Incomplete vaccination, n (%)	63 (58.3)	48 (34.8)	0.002*
Delay in seeking care ≥3 days, n (%)	71 (65.7)	53 (38.4)	<0.001*

*Significant at p<0.05.

Children with pneumonia had significantly lower mean MUAC values and were more frequently incompletely vaccinated and late in seeking care.

3.3. Environmental and infectious factors

Table 2 presents the environmental and infectious factors associated with pneumonia in univariate analysis.

Table 2 Environmental and infectious factors associated with pneumonia (univariate analysis)

Variables	Cases (n = 108)	Controls (n = 138)	Crude OR (95% CI)	p value
Exposure to biomass smoke, n (%)	99 (91.7)	97 (70.3)	4.16 (2.02–8.56)	<0.001
Household overcrowding, n (%)	68 (62.9)	53 (38.4)	2.74 (1.58–4.75)	<0.001
Passive smoking, n (%)	30 (27.8)	17 (12.3)	2.78 (1.39–5.58)	0.01
Confirmed malaria co-infection, n (%)	33 (30.6)	25 (18.1)	1.98 (1.04–3.76)	0.03
HIV positive, n (%)	10 (9.3)	4 (2.9)	3.45 (1.05–11.31)	0.04

Exposure to biomass smoke, household overcrowding, passive smoking, malaria co-infection, and HIV were all significantly associated with pneumonia in univariate analysis.

3.4. Multivariable analysis

Independent predictors of pneumonia included:

- Incomplete vaccination (aOR 2.41; *p* = 0.004)
- Exposure to biomass smoke (aOR 3.87; *p* <0.001)
- Household overcrowding (aOR 2.15; *p* = 0.012)
- Delay in seeking care ≥3 days (aOR 2.64; *p* = 0.002)
- MUAC <110 mm (aOR 1.98; *p* = 0.031)
- Malaria co-infection (aOR 1.87; *p* = 0.046)

Table 3 Multivariable analysis of factors independently associated with pneumonia

Factors	Adjusted OR (95% CI)	p value
Incomplete vaccination	2.41 (1.34–4.35)	0.004
Exposure to biomass smoke	3.87 (1.72–8.73)	<0.001
Household overcrowding	2.15 (1.18–3.93)	0.012
Delay in seeking care ≥3 days	2.64 (1.39–5.00)	0.002
MUAC <110 mm	1.98 (1.06–3.69)	0.031
Malaria co-infection	1.87 (1.01–3.45)	0.046

Exposure to biomass smoke increased the risk of pneumonia by nearly four-fold.

4. Discussion

This case–control study identified several independent risk factors for community-acquired pneumonia in children with SAM in N'Djamena. The most important determinants included incomplete vaccination, exposure to biomass smoke, household overcrowding, delayed care-seeking, severity of malnutrition, and malaria co-infection. These findings align with evidence from other sub-Saharan African settings, indicating a convergence of biological, environmental, and social determinants of respiratory infections in resource-limited environments [7].

Incomplete vaccination was a major factor, likely reflecting gaps in pneumococcal and *Haemophilus influenzae* type b vaccine coverage despite their inclusion in national immunization programs [8]. Similar associations have been documented in Niger and Cameroon, where incomplete vaccination increases pneumonia severity among malnourished children [9].

Exposure to biomass smoke was extremely common and showed a strong independent association with pneumonia. Combustion of solid fuels produces pollutants that impair mucosal immunity and predispose young children to respiratory infections [10,11].

Household overcrowding remained a significant factor after adjusting for nutritional status, highlighting the influence of structural poverty and housing conditions on infection transmission dynamics [12].

The association between MUAC <110 mm and pneumonia underscores the profound immune dysfunction associated with severe malnutrition, including impaired cellular immunity and weakened mucosal defenses [13,14].

Malaria co-infection also increased pneumonia risk, consistent with evidence that malaria-related anemia, systemic inflammation, and respiratory compromise may precipitate or exacerbate lower respiratory tract infections [15,16].

Overall, reducing pneumonia burden among children with SAM requires integrated strategies that extend beyond clinical management. Priority interventions should include:

- Strengthening routine immunization and catch-up programs
- Reducing exposure to household air pollution through clean-cooking initiatives
- Addressing overcrowding and improving housing ventilation
- Promoting early care-seeking and community-level awareness
- Integrating nutritional rehabilitation with comprehensive management of infectious diseases, including malaria

4.1. Strengths and limitations

Strengths of this study include its analytical design and its focus on a high-risk population. However, limitations include single-site recruitment, potential information bias inherent to retrospective data collection, and residual confounding due to unmeasured socioeconomic variables.

Despite these limitations, the findings provide locally relevant evidence to guide clinical and public health interventions aiming to reduce pneumonia in severely malnourished children in Chad.

5. Conclusion

Among children with severe acute malnutrition in N'Djamena, community-acquired pneumonia is strongly associated with modifiable determinants related to immunization, environmental exposures, health care–seeking behavior, nutritional severity, and malaria co-infection. Targeted, integrated interventions addressing these factors are essential to reduce pneumonia-related morbidity and mortality.

Further multicentre and interventional studies are needed to evaluate the effectiveness of combined strategies in the most disadvantaged settings.

Compliance with ethical standards

Disclosure of conflict of interest

No conflict of interest to be disclosed.

Statement of ethical approval

A copy of the ethical approval statement is attached.

Statement of informed consent

A copy of the informed consent statement, which was delivered orally to the parents, is attached.

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