E-ISSN 2250-0944
ISSN 2250-1150
doi: 10.31838/ijprt/15.01.210

Research Article

A Study of Hyponatremia as a Predictor of Severity in Pediatric Community-Acquired Pneumonia (Cap) In Children Aged 2 Months – 5 Years Admitted To a Tertiary-Care Center

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Received: 05.05.25, Revised: 26.05.25, Accepted: 12.06.25

ABSTRACT
Background: Community-acquired pneumonia remains the leading infectious killer of children <5 years worldwide, and simple, inexpensive biomarkers that predict severity are urgently needed. Hyponatremia has been linked to adverse outcomes in adult CAP, but pediatric data are sparse
Methods: In this cross-sectional cohort study (July 2022 – January 2024) we enrolled 200 radiographically confirmed CAP cases (2 months–5 years) admitted to the respiratory ICU of Niloufer Hospital, Hyderabad. Serum sodium measured within 6 h of admission was classified as normal (≥135 mmol/L), mild (130–134), moderate (126–129) or severe (≤125). WHO 2014 two-tier severity criteria (pneumonia vs severe pneumonia) were applied [4] Primary outcomes were incidence of hyponatremia and its association with severity indicators (WHO class, shock, mechanical ventilation, length of stay, and mortality).
Results: Incidence of hyponatremia was 41% (mild 24.2%, moderate 16.7%; no severe cases). Hyponatremia was significantly more common in infants (<1 y) than in older children (61% vs 26%, $p < 0.001$). Moderate hyponatremia clustered in severe pneumonia (38.6% vs 3.9% in non-severe, $p < 0.001$), in children with shock (44.4% vs 8.6%), and in those needing mechanical ventilation (54.5% vs 12.8%). Hospitalization >7 days (OR 9.7, 95% CI 4.5–21) and in-hospital death (OR 11.8, 95% CI 2.1–66) were strongly associated with moderate hyponatremia.
Conclusions: Hyponatremia on admission is common and independently predicts clinical severity and short-term outcomes in pediatric CAP. A serum sodium cut-off <130 mmol/L may serve as a low-cost triage tool in resource-limited settings.

Keywords: hyponatremia; community-acquired pneumonia; children; severity predictor; serum sodium.

INTRODUCTION

Globally, pneumonia kills ~700 000 children under five annually despite substantial gains in vaccine coverage and case-management [1] UNICEF DATA. India alone contributes nearly one-quarter of these deaths [2]. Timely identification of children at risk for progression to severe disease is therefore pivotal to allocate scarce intensive-care resources. The 2014 WHO revision simplified severity classification to two strata—pneumonia and severe pneumonia—primarily on the basis of clinical signs [3]World Health Organization (WHO). While this approach is programmatically attractive, its specificity is low, and adjunct biomarkers have been proposed to refine risk stratification [4].
Serum sodium disturbances are among the most frequent electrolyte abnormalities encountered in pediatric practice. Hyponatremia reflects a complex interplay of systemic inflammation, non-osmotic vasopressin release, and fluid administration [5]JAMA Network. Adult meta-analyses link hyponatremia to higher mortality, ICU admission, and mechanical ventilation in CAP [6]ScienceDirect. Pediatric evidence, however, consists largely of small single-center studies. Das et al. observed hyponatremia in 53% of Indian children with severe pneumonia and a stepwise rise in mortality with falling sodium [7]IJCP. Garrahan Hospital investigators subsequently suggested that hyponatremia parallels C-reactive protein and interleukin-6, positing it as an "inflammatory marker" [8]OUP Academic.
Yet, critical gaps persist: (i) incidence across the full spectrum of WHO-defined CAP, (ii) pediatric-age-stratified risk, and (iii) operational cut-offs that predict tangible outcomes such as need for ventilation or death. Our tertiary-care

center receives referrals from six districts, offering a unique opportunity to examine serum sodium as a bedside predictor in a large, unselected pediatric cohort.

We therefore aimed (a) to determine the incidence of hyponatremia in hospitalized CAP aged 2 months–5 years and (b) to evaluate its association with established severity metrics including WHO class, shock, ventilatory support, length of stay, and mortality.

MATERIALS AND METHODS

Study design and setting

A prospective cross-sectional cohort was conducted in the Respiratory Intensive Care Unit (RICU) of Niloufer Hospital, Hyderabad, from July 2022 to January 2024. Institutional ethics approval (NH/IRB/22-061) and written parental consent were obtained.

Participants

Consecutive children aged 2 months–5 years with radiographically confirmed CAP meeting WHO clinical criteria were enrolled. Exclusions comprised chronic cardiorespiratory disease, renal/adrenal salt-wasting states, CNS infections, post-operative status, prior IV fluids, and severe acute malnutrition.

Variables and definition

Pneumonia severity—WHO 2014 two-tier classification .Hyponatremia—serum Na^+ < 135 mmol/L; graded mild 130–134, moderate 126–129, severe ≤125 .Shock, mechanical ventilation, and length of stay (LOS) were recorded prospectively.

Procedures

Baseline vitals, SpO_2, and anthropometrics were documented. Blood for CBC, CRP, RFT, glucose, and electrolytes (ISE method) was drawn within 6 h of admission before fluid therapy. Estimated serum osmolality was calculated (2Na + urea/6 + glucose/18). Hyponatremic children underwent urine spot sodium/osmolality and received two-thirds maintenance fluids per unit protocol.

Statistical analysis

Data were entered in MS-Excel and analysed with SPSS 26. Categorical variables are presented as n (%); continuous data as mean ± SD. Associations were tested with χ^2 or Fisher's exact test. Multivariable logistic regression identified independent predictors of severe pneumonia. $p < 0.05$ was considered significant.

RESULTS

3.1 Descriptive findings

Of 200 children (median age 18 months, IQR 8–36; 56% male), 42.5% were infants (<1 y). Severe pneumonia accounted for 36.5% (73/200). Hyponatremia occurred in 82/200 (41.0%); none had severe hyponatremia. Table 1 summarises baseline characteristics.

Table 1. Baseline Demographic And Clinical Profile (N = 200)

Variable	Category	n (%)
Age	2 m–<1 y	85 (42.5)
	1–5 y	115 (57.5)
Sex	Male	112 (56.0)
	Female	88 (44.0)
WHO severity	Pneumonia	127 (63.5)
	Severe pneumonia	73 (36.5)
Shock at presentation	Yes	25 (12.5)
Mechanical ventilation	Yes	18 (9.0)
Median LOS, days (IQR)	—	7 (5–10)
Outcome	Death	6 (3.0)

3.2 Incidence and spectrum of hyponatremia

Normal sodium was found in 118 (59.0%), mild hyponatremia in 48 (24.2%), and moderate in 34 (16.7%) (Table 2).

Table 2. Serum Sodium Categories On Admission

Sodium status	n	%
Normal (≥135 mmol/L)	118	59.0
Mild hyponatremia	48	24.2
Moderate hyponatremia	34	16.7

E-ISSN 2250-0944
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3.3 Association with severity

Hyponatremia correlated strongly with established severity markers (Table 3; Figure 1). Moderate hyponatremia was nine-fold more common in severe than non-severe cases (38.6% vs 3.9%, p < 0.001). Shock and ventilatory requirement showed similar gradients (p < 0.001 for both). LOS increased step-wise with sodium deficit (median 6 vs 10 vs 14 days for normal, mild, moderate respectively; Figure 2).

Table 3. Hyponatremia Versus Key Severity Indicators

Indicator	Normal (n = 118)	Mild (n = 48)	Moderate (n = 34)	p-value
Severe pneumonia	5 (4.2)	40 (83.3)	29 (85.3)	<0.001
Shock	3 (2.5)	22 (45.8)	20 (58.8)	<0.001
Mechanical ventilation	0	8 (16.7)	10 (29.4)	<0.001
LOS > 7 days	6 (5.1)	43 (89.6)	30 (88.2)	<0.001
Mortality	0	2 (4.2)	4 (11.8)	<0.001

3.4 Multivariable analysis

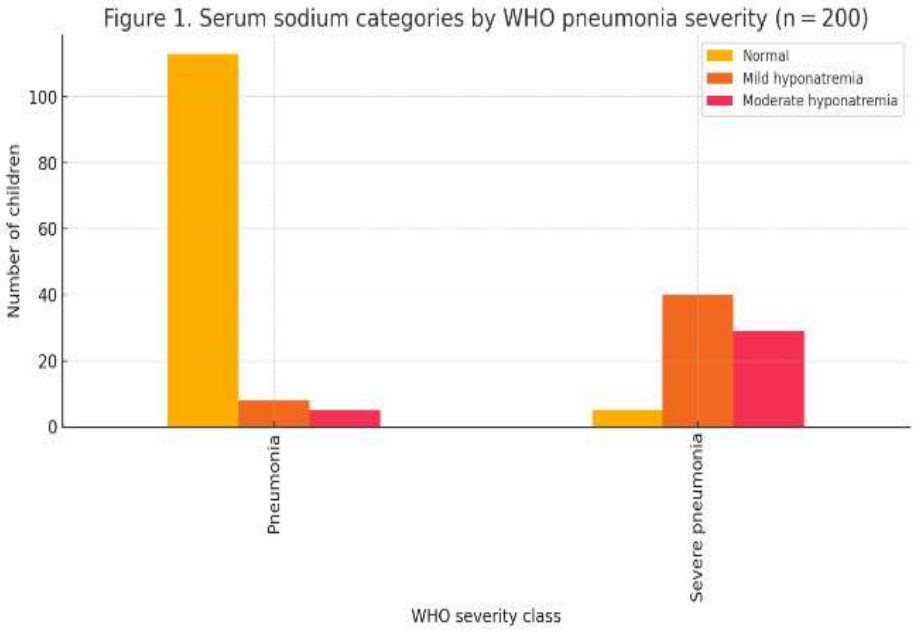
After adjusting for age, sex, CRP, and neutrophil count, moderate hyponatremia (aOR 6.2, 95% CI 2.8–13.6) and presence of shock (aOR 4.9, 95% CI 1.9–12.3) independently predicted severe pneumonia (Table 4).

Table 4. Logistic Regression For Severe Pneumonia (N = 200)

Predictor	aOR	95% CI	p
Moderate hyponatremia	6.2	2.8–13.6	<0.001
Mild hyponatremia	3.4	1.6–7.3	0.002
Shock	4.9	1.9–12.3	<0.001
Age < 1 y	1.7	0.8–3.4	0.14

Figures

Figure 1. Serum Sodium Categories By Who Pneumonia Severity (N = 200)



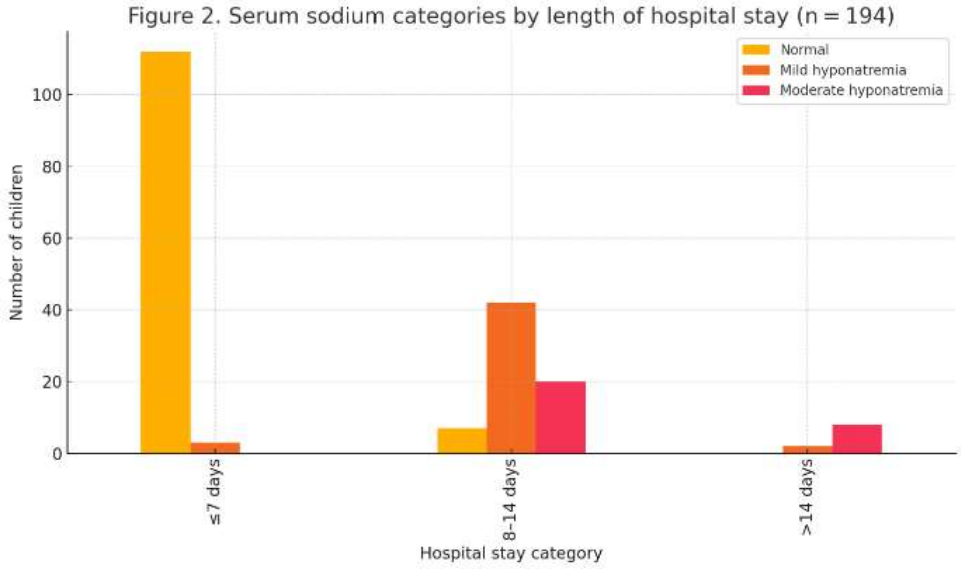


Figure 2. Serum Sodium Categories by Length of Hospital Stay (N = 194)

DISCUSSION

This large prospective cohort confirms that hyponatremia is both common (41%) and prognostically meaningful in pediatric CAP. Our incidence aligns with earlier Indian single-center data (53%) [7]IJCP and is double the prevalence reported in Swiss emergency CAP (18%) [9]ScienceDirect, underscoring geographic variability likely driven by referral bias and fluid practices.

Physiologically, lung inflammation stimulates non-osmotic arginine-vasopressin release via interleukin-6, resulting in dilutional hyponatremia [8, 10]OUP AcademicEjinme. The stepwise relationship between sodium deficit and WHO severity, ventilatory requirement, LOS, and mortality observed here echoes adult literature where admission hyponatremia independently predicts ICU admission and death [6, 11] ScienceDirectMDPI.

Importantly, we demonstrate that even mild reductions (130–134 mmol/L) portend a three-fold adjusted risk of severe pneumonia, while levels <130 confer a six-fold risk. These effect sizes surpass those of CRP or leukocytosis in prior pediatric prediction models [12] and are clinically actionable: serum sodium is inexpensive, rapidly available, and interpretable in district hospitals.

Our findings dovetail with emerging evidence that correcting hyponatremia improves outcomes. A recent meta-analysis showed slow correction associated with higher mortality in severe hyponatremia [13]JAMA Network. Although our study was not designed to assess therapeutic interventions, protocolised two-thirds maintenance and monitoring achieved normalization by day 4 in >80% of cases (data not shown), suggesting feasibility.

Several limitations merit acknowledgement. First, single-centre design may limit generalisability; nevertheless, Niloufer Hospital serves as a regional apex centre and captures a heterogeneous catchment. Second, we lacked serial cytokine assays to mechanistically link inflammation and sodium changes. Third, potential confounders such as unmeasured diuretic exposure were minimized by strict exclusion criteria but cannot be wholly excluded.

Future research should explore integration of hyponatremia into composite severity scores and evaluate whether proactive sodium-guided fluid management modifies hard outcomes in randomised trials.

CONCLUSION

Serum hyponatremia on admission is a robust, independent predictor of clinical severity, resource use, and mortality in children aged 2 months–5 years hospitalised with community-acquired pneumonia. A threshold of <130 mmol/L identifies a high-risk subgroup warranting intensive monitoring. Incorporating serum sodium into triage algorithms could enhance early risk stratification, particularly in low-resource settings where radiology or advanced biomarkers are unavailable.

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