RESEARCH PAPER

Prevalence, Pattern and Clinical Outcomes of Dyselectrolytemia Among Children Admitted to a Tertiary Care Paediatric Emergency Unit

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Received: 15th Jul, 2026 | Revised: 25th Jul, 2026 | Accepted: 5th Aug, 2026 | Available Online: 12th Aug, 2026

ABSTRACT

Background: Electrolyte abnormalities are common among children admitted to emergency and intensive care units and may result from mild illness or life-threatening events. When unrecognised at admission, dyselectrolytemia is associated with increased duration of hospital stay, morbidity and mortality.

Objectives: To determine the prevalence and pattern of dyselectrolytemia at admission to the Emergency Unit (EU) of a tertiary care centre, the effect of intravenous fluids on electrolyte status, and the association of electrolyte imbalance with morbidity and mortality.

Methods: This prospective observational study was conducted in the EU of Indira Gandhi Institute of Child Health, Bengaluru, over one year (January-December 2021). Children aged 1 month to 18 years fulfilling inclusion criteria were enrolled after informed consent. Serum sodium, potassium and chloride were measured at admission; children with abnormal values were followed serially until normalisation. Time to resolution and need for PICU care were recorded.

Results: Of 1035 children enrolled, 516 (49.85%) had electrolyte abnormality at admission. Hyponatremia was the commonest abnormality (469, 45.31%), followed by hyperchloremia (193, 18.65%). The respiratory system was the most frequently involved system (367, 35.5%), followed by infectious etiology (299, 28.9%). Hyponatremia was predominantly associated with infectious illness, hypernatremia with central nervous system involvement, hypokalemia with gastrointestinal illness, and hyperkalemia with renal involvement. Children with electrolyte imbalance at admission had a significantly higher need for PICU care (68.9% vs 31.1%, $p<0.000001$), longer hospital stay ($p=0.00044$), and higher mortality (78.1% of non-survivors had dyselectrolytemia, $p=0.000017$).

Conclusion: Dyselectrolytemia at admission is common among children presenting to a paediatric emergency unit and is an independent contributor to morbidity and mortality irrespective of the primary illness. Serial electrolyte monitoring and timely correction may improve outcomes.

Keywords: Electrolyte imbalance; Dyselectrolytemia; Emergency unit; Critically ill children; Hyponatremia; Mortality

How to cite this article: Raghavi Reddy1 Dr. Alkarani T. Patil2 Dr. Jacqueline A Shah3* Dr. Sathvika Chandrashekara Reddy4 Dr. Priyanka A.R5. Prevalence, Pattern and Clinical Outcomes of Dyselectrolytemia Among Children Admitted to a Tertiary Care Paediatric Emergency Unit. Int J Drug Deliv Technol. 2026;16(78s):743-750. DOI: 10.25258/ijddt.16.78s.85.

INTRODUCTION

Fluid and electrolyte homeostasis is essential for normal organ function. Electrolyte imbalance at admission is an important prognostic indicator in children, irrespective of the primary disease process, and is commonly encountered in both the Emergency Unit (EU) and the Paediatric Intensive Care Unit (PICU).(1) Dyselectrolytemia must be addressed with particular caution, as it is often difficult to reliably assess symptoms and signs in critically ill children, allowing such abnormalities to remain unrecognised and to contribute to morbidity and mortality.(2) The major electrolytes of clinical relevance are sodium, potassium and chloride; derangement of any of these, in either direction, can adversely affect cellular

processes.(3) Early recognition and prompt correction of electrolyte disturbance reduces the requirement for mechanical ventilation, intensive care and prolonged hospitalisation, and favourably influences overall outcome.(4)

While extensive literature exists on electrolyte disturbances arising during a PICU stay, comparatively few studies have specifically examined dyselectrolytemia present at the time of admission. Early identification of electrolyte imbalance at this stage, and institution of appropriate treatment, is associated with a reduced requirement for intensive care and improved outcome — an observation of particular relevance in resource-limited health-care settings. This formed the rationale for the present study.

REVIEW OF LITERATURE

Total body water constitutes approximately 90% of body weight in the fetus, decreasing to about 75% in term neonates, 60% by one year of age, and 50-60% in adolescence; this fluid is distributed between the intracellular and extracellular (plasma and interstitial) compartments.(10-12) Sodium is the principal extracellular cation and chief determinant of plasma osmolality and circulating volume, regulated primarily by the kidney; potassium is the major intracellular cation, vital for neuromuscular and cardiac function and regulated by renal excretion and Na+/K+-ATPase activity; chloride is the major extracellular anion and contributes to acid-base balance.(13-16) Hyponatremia (sodium <135 mEq/L) may be hypovolemic, euvolemic (as in SIADH), or hypervolemic in origin, and ranges in severity from mild nausea and malaise to seizures and coma; correction requires attention to volume status, with hypertonic (3%) saline reserved for symptomatic cases and rapid correction (>8-10 mEq/L/day) avoided due to the risk of osmotic demyelination.(20-23) Hypernatremia (sodium >145 mEq/L) commonly results from free water loss, poor intake, diabetes insipidus, or excess sodium administration, and is managed with gradual correction and frequent monitoring.(24-30) Hypokalemia (potassium <3.5 mEq/L) arises from gastrointestinal or renal losses, poor intake, or intracellular shifts, and may manifest as muscle weakness, ileus, arrhythmia, or respiratory paralysis in severe cases; hyperkalemia (potassium >5.5 mEq/L) is most often related to renal failure, acidosis, or cell lysis, and is managed with calcium gluconate, insulin-dextrose, salbutamol, and, where indicated, sodium bicarbonate or ion-exchange resins.(31-46) Hypochloremia is typically associated with vomiting, diuretic use, or metabolic alkalosis, while hyperchloremia is associated with diarrhoea, renal tubular acidosis, or excess chloride administration.(47-50)

Prior observational studies from varied settings report electrolyte abnormalities in 44-84% of critically ill children, most often hyponatremia, hypokalemia, hypochloremia and hypocalcemia, with imbalance consistently linked to longer PICU stay, greater requirement for ventilatory and inotropic support, acute kidney injury, multi-organ dysfunction, and increased mortality, particularly when multiple abnormalities coexist.(5-9,53,54) These findings collectively underscore the need for routine, serial electrolyte monitoring and standardised correction protocols in children admitted to emergency and critical care settings.

AIMS AND OBJECTIVES

1. To determine the prevalence of dyselectrolytemia at admission in the Emergency Unit (EU) of a tertiary care centre.
2. To describe the pattern of dyselectrolytemia at admission to the EU.
3. To determine the time taken for resolution of dyselectrolytemia and the need for PICU care.

MATERIALS AND METHODS

Study design and setting: This was a prospective observational study conducted in the Emergency Unit (EU) of Indira Gandhi Institute of Child Health (IGICH), Bengaluru, a tertiary care paediatric referral centre, over a period of one year (January 2021 to December 2021). Ethical clearance was obtained from the Institutional Ethics Committee of IGICH prior to commencement of the study (Approval No. IGICH/ACA/PG-MD(PED)/EC-01/2020-21).

Inclusion criteria: All children aged 1 month to 18 years admitted to the EU of IGICH during the study period were included after obtaining informed consent from parents/guardians.

Exclusion criteria: (1) Children with known or diagnosed chronic hepatic or renal disease; (2) children with any pre-existing condition known to cause electrolyte abnormality.

Sample size: Based on a previously reported prevalence of dyselectrolytemia of 44.3%, with 95% confidence (Z=1.96) and absolute precision of 5%, the minimum calculated sample size was 379. A total of 1035 children were enrolled, exceeding this requirement.

Methodology: All children admitted to the EU were triaged and given initial stabilisation. Blood samples were obtained through intravenous or intraosseous access and sent for routine investigations, including serum electrolytes, at the time of admission. Clinical and demographic details were recorded in a pre-structured proforma. Electrolyte abnormalities were defined as follows: hyponatremia, serum sodium <135 mEq/L; hypernatremia, sodium >145 mEq/L; hypokalemia, potassium <3.5 mEq/L (1-5 months), <3.6 mEq/L (6 months-1 year), or <3.3 mEq/L (>1

year); hyperkalemia, potassium >5.5 mEq/L; hypochloremia, chloride <96 mEq/L; and hyperchloremia, chloride >106 mEq/L. Electrolytes were re-measured 6th-hourly, or as per unit protocol, and children with abnormal values at admission were followed serially until normalisation. The time taken for resolution of dyselectrolytemia and the requirement for PICU care were recorded.

Statistical analysis: Data were analysed using appropriate descriptive statistics (frequencies, percentages, mean ± SD). Associations between categorical variables were tested using the Chi-square test, with $p<0.05$ considered statistically significant.

RESULTS

A total of 1035 children admitted to the Emergency Unit during the study period were analysed.

Baseline characteristics: Infants between 1 month and 1 year made up the largest group, 429 children (41.45%), followed by 254 (24.60%) aged 1-5 years, 193 (18.65%) aged 5-10 years, and 159 (15.30%) older than 10. This infant predominance is worth noting given how vulnerable this age group is to fluid shifts. Boys numbered 597 (57.7%) against 438 girls (42.3%), a ratio of roughly 1.36:1. Among the 740 children for whom residence data were available, 488 (66%) were from rural areas, likely reflecting the hospital's catchment population rather than anything disease-specific.

Of the total 576 children (56%) arrived as referrals from other hospitals, while 459 (44%) presented directly. Among referred children, 383 (66.5%) had already received intravenous fluid before reaching us, most often half-strength Dextrose Normal Saline (198 children, 51.7%), followed by Isolyte-P (57, 14.9%) and plain DNS (47, 12.3%). This detail resurfaces later in the discussion, since half-DNS is hypotonic, and hypotonic fluid tends to lower serum sodium.

Table 1. Prevalence and pattern of electrolyte abnormalities at admission (n = 1035)

Electrolyte abnormality	Number	Percentage	Mean ± SD
Any electrolyte abnormality	516	49.85%	-
Hyponatremia (<135 mEq/L)	469	45.31%	132.04 ± 3.94
Hypernatremia (>145 mEq/L)	39	3.77%	151.49 ± 5.83
Hypokalemia (<3.5 mEq/L)	59	5.70%	3.19 ± 0.35
Hyperkalemia (>5.5 mEq/L)	78	7.54%	6.11 ± 0.51
Hypochloremia (<96 mEq/L)	100	9.66%	91.92 ± 4.43
Hyperchloremia (>106 mEq/L)	193	18.65%	110.20 ± 6.64

Roughly half the 516 of 1035 children (49.85%) — had some electrolyte abnormality at admission. Hyponatremia dominated the pattern, present in 469 children (45.31%), followed by hyperchloremia in 193 (18.65%), hypochloremia in 100 (9.66%), hyperkalemia in 78 (7.54%), and hypokalemia in 59 (5.7%). Hypernatremia was the least frequent finding, seen in only 39 children (3.77%).

Table 2. System or illness underlying admission (n = 1035)

System/Illness	Number	Percentage
Respiratory illness	367	35.50%
Infections	299	28.90%
CNS/neurological illness	250	24.20%
Cardiac (CVS)	68	6.60%
Gastrointestinal illness	44	4.25%
Haematological	37	3.60%
Metabolic causes	23	2.20%
Others	22	2.20%
Renal	22	2.10%

Respiratory illness accounted for the largest share of admissions (367 children, 35.5%), followed by infection (299, 28.9%) and neurological illness (250, 24.2%). Renal causes were the least frequent, seen in just 22 children (2.1%).

A fairly clear pattern emerged when specific illnesses were matched against specific electrolyte problems. Among children with infection, 176 of 299 (59%) had hyponatremia — the single largest share observed for any group. Hypernatremia, by contrast, was more frequent among children with neurological illness, 21 of 250 (8%). Hypokalemia clustered strongly with gastrointestinal disease, 24 of 44 (54.5%), while hyperkalemia was most common among children with renal involvement, 8 of 22 (36.4%). These patterns are broadly consistent with known physiology: gut losses deplete potassium, renal failure allows it to accumulate, and sick children with infections are prone to inappropriate ADH release that lowers sodium.

Table 3. Sodium status against system involved

System involved	Hyponatremia	Normal sodium	Hypernatremia
Respiratory (n=367)	135 (36.8%)	232 (63.2%)	0 (0%)
CVS (n=68)	30 (44%)	34 (50%)	4 (6%)
CNS (n=250)	102 (41%)	127 (51%)	21 (8%)
Gastrointestinal (n=44)	18 (41%)	23 (52%)	3 (7%)
Renal (n=22)	8 (36.4%)	11 (50%)	3 (13.6%)

Haematology (n=37)	17 (46%)	19 (51%)	1 (3%)
Infections (n=299)	176 (59%)	119 (40%)	4 (1%)
Metabolic (n=23)	9 (39%)	13 (56.5%)	1 (4.5%)
Others (n=22)	5 (22.7%)	17 (77.3%)	0 (0%)

Table 4. Potassium status against system involved

System involved	Hypokalemia	Normal potassium	Hyperkalemia
Respiratory (n=367)	12 (3.3%)	355 (96.7%)	0 (0%)
CVS (n=68)	5 (7%)	61 (90%)	2 (3%)
CNS (n=250)	10 (4%)	234 (93.6%)	6 (2.4%)
Gastrointestinal (n=44)	24 (54.5%)	18 (41%)	2 (4.5%)
Renal (n=22)	4 (18.2%)	10 (45.5%)	8 (36.4%)
Haematology (n=37)	4 (10.8%)	26 (70.3%)	7 (18.9%)
Infections (n=299)	17 (5.7%)	277 (92.6%)	5 (1.7%)
Metabolic (n=23)	0 (0%)	18 (78%)	5 (22%)
Others (n=22)	1 (4.5%)	20 (91%)	1 (4.5%)

Table 5. Age group against each electrolyte abnormality

Electrolyte	<1 yr	1-5 yr	5-10 yr	>10 yr	p value
Hyponatremia (n=469)	173 (37%)	118 (25.1%)	97 (20.7%)	81 (17.2%)	0.2051 (NS)
Hypernatremia (n=39)	21 (53.9%)	8 (20.5%)	6 (15.4%)	4 (10.2%)	-
Hypokalemia (n=59)	20 (34%)	12 (20.3%)	18 (30.5%)	9 (15.2%)	0.0014*
Hyperkalemia (n=78)	51 (65.4%)	13 (16.7%)	10 (12.8%)	4 (5.1%)	-
Hypochloremia (n=100)	37 (37%)	23 (23%)	24 (24%)	16 (16%)	0.0344*
Hyperchloremia (n=193)	92 (47.5%)	53 (27.5%)	23 (12%)	25 (13%)	-

Electrolyte abnormality of any type was more common in children under 1 year than in any other age group. Potassium and chloride abnormalities showed a statistically significant association with age (p=0.0014 and p=0.0344), whereas sodium abnormality, though also more frequent in infants, did not reach significance across age groups (p=0.2051).

Table 6. Outcomes in children with and without electrolyte imbalance at admission

Outcome measured	Imbalance present (n=516)	Imbalance absent (n=519)	p value
Needed ICU care (n=209)	144 (68.9%)	65 (31.1%)	<0.000001*
Hospital stay beyond 14 days (n=77)	61 (79.2%)	16 (20.8%)	0.00044*
Died (n=141)	110 (78.1%)	31 (21.9%)	0.000017*

Overall, 209 children (20.2%) required PICU care. Of these, 144 (68.9%) had an electrolyte abnormality at admission, against only 65 (31.1%) with normal values — a highly significant difference (p<0.000001). Among children admitted to PICU, 77 (36.8%) needed mechanical ventilation, most often for 48 hours to 7 days (45 children, 58.45%). Ventilation duration was numerically longer in children with electrolyte imbalance, though this difference fell just short of statistical significance (p=0.0832), and should be interpreted cautiously.

Hospital stay was significantly longer among children with electrolyte imbalance at admission (p=0.00044). Of the 871 children eventually discharged, those with electrolyte imbalance made up 61 of 77 (79.2%) of stays beyond 14 days, compared with 58.5% of stays under a week. Resolution of the abnormality itself was generally swift: 171 children (60.2%) normalised within a day, 108 (38%) took between 1 and 7 days, and only 5 (1.8%) took longer than a week, giving a mean resolution time of 2 ± 1.57 days.

Across the whole cohort, 871 children (84.2%) were discharged, 23 (2.22%) left against medical advice, and 141 (13.65%) died. Electrolyte imbalance at admission was present in 110 of these 141 deaths (78.1%), a strongly significant association (p=0.000017) and, arguably, the central finding of this study: dyselectrolytemia at the door predicted a substantially worse outcome, irrespective of the underlying illness.

COMPARISON WITH OTHER PUBLISHED STUDIES

To situate these findings, we compared them against five previously published studies addressing similar questions: Naseem et al. from Karachi,(5) Khanappan et al. from Karnataka,(6) Panda et al. from Tamil Nadu,(7) Elala et al. from Ethiopia,(8) and Ebrahim et al. from Benha University.(9)

Table 7. Baseline features compared across studies

Feature	Nasee	Khanapp	Pand	Elal	Ebrahi	Prese

	m(5)	an(6)	a(7)	a(8)	m(9)	nt study
Place	Karachi	Karnataka	Tamil Nadu	Ethiopia	Benha Univ.	Bengaluru
Sample size	101	153	729	384	120	1035
Age group	1mo-12yr	1mo-15yr	29d-12yr	0-15yr	1mo-18yr	1mo-18yr
Male:Female	1.52:1	1.2:1	-	1.2:1	1:1.3	1.36:1
Prevalence of imbalance	84.15%	83.7%	44.31%	45.1%	-	49.85%

With 1035 children, our sample was substantially larger than any comparator, more than twice the next largest (Panda et al., 729 children), which lends our estimates somewhat more statistical stability. Our overall prevalence (49.85%) sits close to Panda(7) and Elala,(8) but well below Naseem(5) and Khanappan.(6) The explanation is straightforward: those two studies included five electrolytes, calcium among them, whereas ours was limited to sodium, potassium and chloride — a narrower net naturally catches fewer abnormalities.

Table 8. Pattern of electrolyte abnormality compared across studies

Electrolyte	Naseem(5)	Khanappan(6)	Panda(7)	Elala(8)	Ebrahim(9)	Present study
Hyponatremia	23.5%	31.4%	27.4%	23.2%	23.3%	45.31%
Hypernatremia	37.6%	7.8%	3.6%	16.7%	11.7%	3.77%
Hypokalemia	30.6%	12.4%	14.0%	22.1%	38.3%	5.70%
Hyperkalemia	18.8%	6.5%	6.3%	11.2%	22.5%	7.54%
Hypochloremia	-	51%	-	-	-	9.66%
Hyperchloremia	-	7.8%	-	9.4%	-	18.65%
Hypocalcemia	57.6%	19%	-	15.4%	71.7%	-

Hyponatremia dominated our data by a wide margin, 45.31% against a range of 23-31% elsewhere. Part of the reason likely traces to fluid practice: over half the children given IV fluid before referral had received half-strength DNS, a hypotonic solution. Hypotonic fluids are known to lower sodium,(56) whereas isotonic fluids are linked with fewer cases of hyponatremia.(57) Hyperchloremia, our second most frequent abnormality (18.65%), also exceeded Elala(8) (9.4%) and Khanappan(6) (7.8%), plausibly reflecting our larger share of infectious and neurological illness, both often managed with chloride-rich resuscitation.

Hypokalemia (5.7%) and hyperkalemia (7.54%) were both lower here than in most comparator studies, most likely because fewer of our children had the gastrointestinal or renal illness that typically drives these shifts. Hypernatremia, our least frequent finding (3.77%), matched almost exactly with Panda's figure (3.57%).(7) Calcium was not assessed in this study, so direct comparison is not possible, though it is worth noting that hypocalcemia was the leading abnormality in both Naseem's(5) and Ebrahim's(9) cohorts — our overall prevalence figures might well look different had calcium been included.

Table 9. System involved, compared across studies

System	Naseem(5)	Khanappan(6)	Panda(7)	Ebrahim(9)	Present study
Respiratory	30.7%	22.2%	29.5%	17.5%	35.5%
CVS	11.9%	5.9%	6.9%	5%	6.6%
CNS	25.7%	32.7%	26.7%	17.5%	24.2%
GIT	4.0%	19%	11%	20%	4.25%
Renal	-	-	3.6%	22.5%	2.1%
Infection	17.8%	18.3%	8.4%	10%	28.9%

Respiratory illness led admissions in our cohort, as in Naseem(5) and Panda,(7) whereas Khanappan's group(6) found neurological illness slightly ahead. Renal illness was our least common cause of admission, consistent with our comparatively low hyperkalemia figure, since renal disease made up over a fifth of cases in Ebrahim's cohort.(9) Such cross-study differences most likely reflect geography, referral patterns, and local disease burden rather than any underlying biological discrepancy.

DISCUSSION

This study enrolled 1035 children aged 1 month to 18 years admitted to a tertiary care paediatric Emergency Unit, representing one of the larger cohorts reported in the literature on admission dyselectrolytemia. Male predominance (57.7%) was consistent with the findings of Naseem et al.,(5) Khanappan et al.,(6) and Elala et al.,(8) although Ebrahim et al.(9) reported a female preponderance.

The overall prevalence of electrolyte imbalance in the present study (49.85%) was comparable to that reported by Panda et al. (44.31%)(7) and Elala et al. (45.1%),(8) but lower than the figures reported by Naseem et al. (84.15%)(5) and Khanappan et al. (83.7%),(6) a difference attributable to the latter studies including all five major electrolytes

(including calcium), whereas the present study evaluated only sodium, potassium and chloride.

Hyponatremia was the single most common electrolyte abnormality in this cohort (45.31%), a finding that parallels the pattern reported by Panda et al.(7) and Elala et al.(8) The comparatively high prevalence of hyponatremia in the present study may be explained by the widespread use of hypotonic maintenance fluids (particularly half-strength DNS, used in over half of children who received intravenous fluids prior to referral) — an observation consistent with reports that hypotonic fluid administration lowers serum sodium,(56) whereas isotonic fluid use is associated with fewer cases of hyponatremia.(57) Hyperchloremia, the second most common abnormality in this study (18.65%), was notably higher than reported by Elala et al. (9.4%)(8) and Khanappan et al. (7.8%),(6) plausibly related to the higher proportion of infectious and neurological illness in the present cohort. Hyperkalemia (7.54%) and hypokalemia (5.7%) were comparatively less frequent than in most other reported series, consistent with the relatively low proportion of renal and gastrointestinal illness in this cohort, since hyperkalemia and hypokalemia were most strongly associated with renal and gastrointestinal involvement respectively — an association also reported by Panda et al.(7) and Elala et al.(8)

The predominance of dyselectrolytemia among infants below one year of age in this study is consistent with the recognised vulnerability of this age group to fluid and electrolyte disturbance, given their dependence on caregivers for fluid intake,(55) and supports maintaining a lower threshold for correction of electrolyte abnormalities in this population.

Electrolyte imbalance at admission was strongly and significantly associated with the need for PICU care ($p<0.000001$), prolonged hospital stay ($p=0.00044$), and mortality ($p=0.000017$) in this study, in keeping with previous reports linking dyselectrolytemia to poor prognosis regardless of the primary illness.(1,4,7,8) Although the duration of mechanical ventilation was numerically longer among children with electrolyte imbalance, this difference did not reach statistical significance in the present study, in contrast to the findings of Naseem et al., who reported a markedly higher requirement for mechanical ventilation among children with electrolyte imbalance.(5) The overall mortality in this study (13.65%) was lower than that reported by Panda et al. (23.73%)(7) and Naseem et al. (22.7%),(5) but the proportion of non-survivors with electrolyte imbalance at admission (78.1%) was substantial and statistically significant, reinforcing dyselectrolytemia as an important, potentially modifiable, predictor of outcome.

Limitations of this study include its single-centre design, restriction of analysis to three electrolytes (sodium, potassium and chloride) without inclusion of calcium or magnesium, and the observational nature of the design, which precludes causal inference regarding the relationship between intravenous fluid composition and electrolyte outcomes.

CONCLUSION

Electrolyte abnormalities are common among children admitted to a tertiary care paediatric Emergency Unit and pose a diagnostic and therapeutic challenge, as they may arise from both mild illness and life-threatening conditions. The presence of dyselectrolytemia at admission significantly increases the need for intensive care, duration of hospital stay, and mortality, independent of the primary disease process. Serial monitoring of electrolytes and timely, judicious correction are essential to improving survival in critically ill children, and a lower threshold for screening and intervention is warranted in infants, who appear disproportionately affected.

SUMMARY

- A total of 1035 children admitted to the EU were enrolled; 597 (57.7%) were male and 438 (42.3%) female (M:F 1.36:1); 429 (41.45%) were less than 1 year of age.
- Electrolyte abnormality at admission was seen in 516 (49.85%) children, most commonly hyponatremia (45.31%) followed by hyperchloremia (18.65%).
- Electrolyte abnormality was more common in infants; hyponatremia was most associated with infectious etiology, hypernatremia with CNS involvement, hypokalemia with gastrointestinal illness, and hyperkalemia with renal involvement.
- The mean time to resolution of dyselectrolytemia was 2 ± 1.57 days.
- PICU care was required in 209 (20.2%) children, of whom 144 (68.9%) had electrolyte imbalance at admission.
- Duration of hospital stay and mortality were significantly higher in children with electrolyte imbalance at admission ($p=0.00044$ and $p=0.000017$ respectively); 110 (78.1%) of 141 deaths occurred in children with dyselectrolytemia.

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