

Article

Clinical Spectrum, Risk Factors, and Immediate Outcomes in Hypernatremic Dehydration in Infants Admitted to the Pediatrics Department of Bacha Khan Medical Complex, Gajju Khan Medical College, Sawabi

Muhammad Kashif Khan¹, Sijad ur Rehman¹, Haji Gul¹, Inayatullah¹, Ahmad Raza Nasir¹, Usman Wajid²

¹ Department of Paediatric Medicine, Gajju Khan Medical College, Swabi, Pakistan

² University Institute of Biochemistry and Biotechnology, Pir Mehr Ali Shah Arid Agriculture University, Rawalpindi, Pakistan

Correspondence:

wajidusman323@gmail.com

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ABSTRACT

Background: Hypernatremic dehydration in infants is a critical electrolyte imbalance associated with significant morbidity and mortality, particularly in low-resource settings. Despite its severity, limited data exist from regional healthcare centers on its clinical spectrum and outcomes, necessitating targeted investigation. **Objective:** To assess the clinical spectrum, associated risk factors, and immediate outcomes of hypernatremic dehydration in infants admitted to a tertiary care pediatric department. **Methods:** This observational cross-sectional study included 183 infants aged ≤ 12 months with serum sodium >145 mEq/L admitted to the Pediatrics Department of Bacha Khan Medical Complex. Infants with congenital renal or metabolic disorders were excluded. Data on demographics, clinical features, feeding history, treatment, and outcomes were collected via a validated structured questionnaire. Ethical approval was obtained from the IRB, adhering to the Declaration of Helsinki. Descriptive and inferential statistics were performed using SPSS v27, including chi-square tests for associations. **Results:** Among 183 infants, 54.1% were male; 78.7% had sodium levels <155 mEq/L. Fever (82%), diarrhea (80.3%), and poor feeding (77%) were most common. Elevated sodium levels were significantly associated with prolonged hospital stay ($p = 0.017$). **Conclusion:** Early recognition and targeted fluid management are essential to reduce hospital stay and improve outcomes in infants with hypernatremic dehydration. Findings support caregiver education and timely intervention as clinical priorities.

Keywords: Hypernatremic dehydration, Infants, Fluid therapy, Clinical outcomes, Risk factors, Pediatric care, Electrolyte imbalance.

INTRODUCTION

Hypernatremic dehydration is a life-threatening electrolyte disturbance that occurs when water loss exceeds sodium loss, leading to elevated serum sodium concentrations. Infants are particularly vulnerable due to their immature renal function, high surface area-to-volume ratio, and limited physiological reserves. This imbalance can severely affect the central nervous system and other vital organs, making early diagnosis and treatment critical. In neonates and infants, hypernatremia may arise from several causes including diarrhea, vomiting, inadequate breastfeeding, improper formula preparation, and, less commonly, conditions like diabetes insipidus. Symptoms may emerge as early as the tenth day of life and may include lethargy, irritability, fever, vomiting, or poor feeding. Despite these clinical signs, the presentation can be deceptively mild, leading to delayed recognition and increased morbidity or mortality (1,2).

Neuroimaging findings in severe cases often reveal venous thrombosis, intracranial hemorrhages, osmotic demyelination, and white matter injuries, underscoring the urgency of timely correction (3). In a retrospective review of hospitalized pediatric patients with hypernatremia, inadequate fluid intake was identified as the leading cause, and a significant proportion of patients had comorbid conditions such as neurological impairment, with a reported mortality of 16% (4). Another study observed that first-born infants, those with significant postnatal weight loss, and those with poor feeding practices are at greater risk of developing hypernatremic dehydration within the first 10 days of life (5). Rapid correction of serum sodium levels is discouraged due to the risk of cerebral edema, and clinical guidelines generally recommend a gradual reduction of no more than 0.5 mEq/L per hour (5).

Previous studies have demonstrated a strong association between the severity of hypernatremia and neurodevelopmental delays, with nearly a quarter of affected infants showing deficits at 6 months of age. This risk appears to decrease over time but remains elevated compared to healthy controls (6). Sociodemographic variables such as rural residency and limited parental awareness further complicate timely identification and management of the condition (7). Local data also indicate a high case fatality rate in settings with limited neonatal intensive care support, particularly where exclusive breastfeeding is not adequately monitored or supplemented (8). While international data on neonatal hypernatremia are growing, there remains a paucity of region-specific research from South Asia, where neonatal dehydration due to diarrheal illness and poor feeding practices remains a major public health challenge.

The current study aims to address this critical gap in knowledge by examining the clinical spectrum, risk factors, and immediate outcomes of hypernatremic dehydration in infants admitted to the Pediatrics Department of Bacha Khan Medical Complex, Gajju Khan Medical College, Swabi. By identifying the early warning signs, associated morbidities, and predictors of poor outcomes, this study seeks to inform evidence-based strategies for early intervention, parental education, and improved clinical management of at-risk neonates. It is hypothesized that infants with more severe hypernatremia will have longer hospital stays and worse clinical outcomes, emphasizing the need for routine screening, caregiver education, and standardized treatment protocols in pediatric care settings.

MATERIAL AND METHODS

This observational cross-sectional study was conducted over a defined period at the Pediatrics Department of Bacha Khan Medical Complex, affiliated with Gajju Khan Medical College, Swabi, Khyber Pakhtunkhwa, Pakistan. The study population comprised infants aged up to 12 months who were admitted with a confirmed diagnosis of hypernatremic dehydration, defined as serum sodium levels exceeding 145 mEq/L. Participants were recruited through consecutive non-probability sampling based on predefined inclusion and exclusion criteria. Infants with known congenital renal anomalies, metabolic disorders, or those receiving diuretics or corticosteroids were excluded to minimize potential confounding variables. The study was approved by the Institutional Review Board (IRB) of Gajju Khan Medical College under protocol number GKMC/IRB/2023/HD-17. Informed consent was obtained in writing from the parents or legal guardians of all participants after explaining the study's aims, procedures, and risks. Participant confidentiality was strictly maintained through anonymized data handling and secure digital storage.

Data collection was carried out using a structured, pretested questionnaire developed by the research team in consultation with pediatric specialists. The questionnaire covered demographic details, clinical symptoms, feeding practices, comorbidities, prior medical history, and treatment details. It was reviewed for content validity by two independent pediatricians, and minor adjustments were made based on

feedback prior to final use. All clinical assessments were performed by attending pediatricians following hospital protocols. Serum sodium levels were measured at admission using standard automated analyzers. Primary outcomes included the clinical spectrum and immediate outcomes (recovery, referral, or mortality). Secondary outcomes assessed the association between serum sodium levels and hospital stay duration, symptom severity, and treatment modality. Operational definitions were established for key clinical indicators: "severe dehydration" included sunken fontanelle, decreased skin turgor, and dry mucous membranes; "poor feeding" was defined as refusal to suck or inadequate intake reported by caregivers over 24 hours. No imaging was employed as part of this study protocol.

Statistical analysis was conducted using IBM SPSS Statistics version 27. Descriptive statistics were computed for demographic and clinical characteristics, including frequencies and percentages for categorical variables and means or medians for continuous variables, as appropriate. The chi-square test was applied to explore associations between serum sodium levels (categorized as <155 mEq/L or ≥ 155 mEq/L) and outcomes such as duration of hospital stay and discharge status. A significance threshold of $p < 0.05$ was used. No imputation methods were applied, as cases with missing critical outcome data were excluded from the final analysis. Confounding variables such as pre-existing comorbidities and feeding methods were considered in the interpretation of outcomes, although no multivariate regression analysis was performed due to the cross-sectional design and sample size limitations.

This study adhered to the ethical principles outlined in the Declaration of Helsinki. All efforts were made to ensure the welfare and rights of participants, including non-coercive participation and the right to withdraw at any stage. The methodological rigor, ethical safeguards, and statistical approach adopted in this study were designed to ensure the reproducibility and transparency of findings within the pediatric research context.

RESULTS

A total of 183 infants diagnosed with hypernatremic dehydration were enrolled in the study. Of these, complete data were available for 151 participants, which were used in the inferential statistical analyses. The age distribution revealed that 32.8% of infants were between 4–6 months, followed by 25.7% in the 7–9 months group, 24.6% in the 0–3 months group, and 16.9% in the 10–12 months category. Males accounted for a slightly higher proportion (54.1%) than females (45.9%). The majority (78.7%) of infants presented with serum sodium levels between 145.0 and 155.0 mEq/L, while 21.3% had levels ≥ 155.0 mEq/L.

Clinically, the most frequently reported symptoms were fever (82.0%), diarrhea (80.3%), poor feeding (77.0%), vomiting (74.9%), and dry mucous membranes (76.5%). Neurological signs such as irritability (44.8%) and sunken fontanelle (33.9%) were less common but clinically significant. Cardiovascular signs included tachycardia in 82.0% and hypotension in 19.1% of infants. Breastfeeding was the predominant feeding method

Table 1. Demographic Distribution and Sodium Levels of Study Participants (N = 151)

Characteristic	Frequency (n)	Percentage (%)
Age Group		
0–3 months	45	24.6
4–6 months	60	32.8
7–9 months	47	25.7
10–12 months	31	16.9
Gender		
Male	82	54.1
Female	69	45.9
Serum Sodium Levels		
<155.0 mEq/L	119	78.7
≥155.0 mEq/L	32	21.3

Table 2. Clinical Presentation and Feeding Practices of Infants with Hypernatremic Dehydration

Clinical Feature	Yes n (%)	No n (%)
Diarrhea	147 (80.3%)	36 (19.7%)
Vomiting	137 (74.9%)	46 (25.1%)
Fever	150 (82.0%)	33 (18.0%)
Poor Feeding	141 (77.0%)	42 (23.0%)
Dry Mucous Membranes	140 (76.5%)	43 (23.5%)
Decreased Skin Turgor	98 (53.6%)	85 (46.4%)
Sunken Fontanelle	62 (33.9%)	121 (66.1%)
Tachycardia	150 (82.0%)	33 (18.0%)
Hypotension	35 (19.1%)	148 (80.9%)
Breastfeeding	123 (67.2%)	–
Formula Feeding	31 (16.9%)	–
Mixed Feeding	29 (15.8%)	–

(67.2%), while 16.9% were formula-fed, and 15.8% received mixed feeding. In terms of treatment and outcomes, 88.5% received oral rehydration therapy, and 17.5% required intravenous fluids, indicating more severe dehydration. Most infants (78.1%) were

discharged within 1–2 days; however, 21.9% required hospitalization beyond 2 days. Regarding outcomes, 67.2% recovered, 16.9% were referred to higher care facilities, and 15.8% unfortunately expired.

Table 3. Treatment Administered and Clinical Outcomes

Parameter	Frequency (n)	Percentage (%)
Oral Rehydration Therapy	162	88.5
Intravenous Fluids	32	17.5
Hospital Stay 1–2 Days	143	78.1
Hospital Stay >2 Days	40	21.9
Recovered	123	67.2
Referred	31	16.9
Expired	29	15.8

Chi-square analysis was conducted to identify associations between sodium level categories and clinical outcomes. No significant associations were found between sodium level categories and symptom duration ($\chi^2 = 3.21$, $p = 0.199$) or

discharge outcome ($\chi^2 = 1.14$, $p = 0.566$). However, a statistically significant relationship was observed between sodium level and hospital stay duration ($\chi^2 = 5.63$, $p = 0.017$), suggesting that higher sodium levels may lead to prolonged hospitalization.

Table 4. Association Between Sodium Levels and Clinical Parameters

Variable	<155 mEq/L	≥155 mEq/L	χ^2	p-value
Symptom Duration (<1, 1–3, 4–7 days)	144	39	3.21	0.199
Outcome (Recovered, Referred, Expired)	144	39	1.14	0.566
Hospital Stay Duration (1–2 vs. >2 days)	118	25	5.63	0.017*

*Statistically significant at $p < 0.05$

Clinically, this result implies that infants presenting with more severe hypernatremia are more likely to experience extended hospital stays, potentially due to complications such as acute kidney injury or sepsis. No unexpected inverse trends were noted; however, the absence of association between sodium levels and mortality or discharge status may reflect the success of early intervention in many cases or limitations due to sample size. Additionally, the referral rate of nearly 17% suggests a substantial proportion of cases required tertiary care, highlighting the need for improved early detection and resource allocation in primary settings.

DISCUSSION

This study highlights the clinical spectrum, risk factors, and immediate outcomes associated with hypernatremic dehydration in infants admitted to a tertiary care pediatric unit. The findings reveal that the condition most frequently affects infants between 4 to 6 months of age, with diarrhea, fever, and poor feeding being the most prevalent presenting symptoms. A significant association was observed between elevated serum sodium levels (≥ 155 mEq/L) and prolonged hospital stay, suggesting that hypernatremia severity is a key determinant of clinical course and recovery duration. However, no statistically significant relationship was observed between sodium levels and symptom duration or discharge outcomes, indicating that while hypernatremia prolongs hospitalization, early management may mitigate mortality and immediate clinical deterioration (8, 11-15).

These findings are consistent with previously published data indicating that hypernatremic dehydration is commonly associated with inadequate feeding, particularly in exclusively breastfed infants, and carries a high risk of morbidity and mortality if not promptly managed (1,2). Our observed case fatality rate of 15.8% closely aligns with the 16% mortality reported in a pediatric cohort study of hospital-acquired hypernatremia, where delayed correction was significantly associated with poor outcomes (4). Moreover, the median age at presentation in our cohort mirrors the age range identified in earlier South Asian and Middle Eastern studies, underscoring the vulnerability of neonates in the first weeks of life (6,7). Our data also reinforce findings from previous literature that infants with sodium levels above 155 mEq/L are more likely to require extended inpatient care, a trend also noted in the prospective analysis by Boskabadi et al., which showed increased neurodevelopmental risks and hospitalization length in this subgroup (13-16).

Interestingly, the lack of significant association between serum sodium levels and outcomes at discharge in our study contrasts with earlier research that links hypernatremia severity to increased mortality and long-term complications such as seizures and developmental delays (5,6). This discrepancy may be attributed to the timely interventions administered at our study site or potential limitations in follow-up duration. Furthermore, while our study confirms the importance of diarrhea and poor feeding as prominent risk factors, the relative underreporting of seizures or convulsions as presenting features diverges from the patterns described in neuroimaging-based

studies (3,10). These differences may reflect population-level variations in etiology, reporting practices, or availability of diagnostic resources such as imaging.

Mechanistically, the development of hypernatremia in neonates often results from disproportionate water loss due to diarrhea or fever, compounded by inadequate fluid replacement. In breastfed infants, insufficient milk transfer—especially in the early postnatal days—can exacerbate this imbalance, leading to a hyperosmolar state that adversely affects the brain, kidneys, and vasculature (2,3). Our study underscores the clinical relevance of identifying high-risk infants early, particularly those presenting with signs of dehydration such as dry mucous membranes, sunken fontanelle, and poor feeding. These symptoms, though non-specific, should prompt immediate electrolyte evaluation and careful fluid management to prevent neurological sequelae (16).

The study's strengths lie in its prospective design, relatively large sample size, and real-world clinical setting, which enhances the relevance of findings to routine pediatric care in resource-limited environments. However, several limitations must be acknowledged. First, the study was conducted at a single center, which may limit the generalizability of results to broader populations. Second, although we collected comprehensive data at admission, the absence of long-term neurodevelopmental follow-up restricts our ability to evaluate delayed outcomes. Third, while statistical associations were explored using chi-square analysis, the lack of multivariate regression may have limited the detection of independent predictors of adverse outcomes. Additionally, missing data for some variables reduced the sample size for inferential analysis from 183 to 151, which may have impacted statistical power (17).

Future research should focus on multicenter studies with larger and more diverse populations to validate these findings and explore long-term neurological and developmental outcomes. Incorporating neuroimaging, serum osmolality, and more granular feeding assessments may help elucidate pathophysiological mechanisms further. Interventional studies evaluating early breastfeeding support and caregiver education in preventing hypernatremia would also be valuable. Moreover, the development of standardized clinical protocols for the gradual correction of serum sodium levels in neonates could significantly reduce the burden of complications associated with both under- and over-correction (17, 18).

CONCLUSION

This study identified the clinical spectrum, associated risk factors, and immediate outcomes of hypernatremic dehydration in infants admitted to the Pediatrics Department of Bacha Khan Medical Complex, highlighting diarrhea, fever, and poor feeding as the most prevalent presentations. A significant association between higher serum sodium levels and prolonged hospital stay underscores the impact of hypernatremia severity on clinical course, while early management appears effective in reducing mortality. These findings emphasize the need for heightened clinical vigilance, timely diagnosis, and standardized fluid management protocols to improve outcomes in this vulnerable

population. From a public health perspective, the results advocate for enhanced caregiver education on infant feeding practices and early signs of dehydration. Future research should focus on long-term neurodevelopmental outcomes and preventive strategies in community settings to reduce the burden of hypernatremic dehydration in infants.

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