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Frequency of Hypokalemia in Children with Acute Watery Diarrhea

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ABSTRACT

Acute watery diarrhea (AWD) remains a major cause of pediatric admissions, and electrolyte disturbances account for much of its morbidity. Hypokalemia is clinically important, yet its relationship with serum chloride is not consistently reported in hospital-based studies. **Objective:** To determine the frequency of hypokalemia among hospitalized children with AWD and examine its association with serum chloride categories and selected demographic and clinical factors. **Methods:** An analytical cross-sectional study was conducted on children aged 6 months to 12 years admitted with AWD. Data on demographics, clinical features, and laboratory parameters (serum potassium, sodium, chloride, bicarbonate, and acid-base status) were collected using a structured proforma. Hypokalemia was defined as serum potassium <3.5 mmol/L. Associations were assessed using the Chi-square test, with effect size reported as Cramér's V. **Results:** A total of 103 children were analyzed. Hypokalemia was present in 58.3% of cases. Serum chloride was the only variable significantly associated with hypokalemia ($\chi^2 = 6.66$, df = 2, p = 0.036; Cramér's V = 0.25). Hypokalemia was most frequent in hypochloremia (77.3%) and least frequent in hyperchloremia (30.0%). No significant associations were observed with age, sex, nutritional status, dehydration, sodium, bicarbonate, or categorical acid-base status. **Conclusions:** Hypokalemia is common in pediatric AWD and is significantly associated with serum chloride categories. Routine electrolyte testing that includes chloride, together with timely potassium correction and fluid planning, is essential to improve outcomes.

INTRODUCTION

Diarrheal disease is a leading cause of morbidity and mortality in children worldwide. According to the World Health Organization (2024), it is the third most common cause of death among children aged 1–59 months, accounting for hundreds of thousands of deaths annually and nearly 1.7 billion episodes of childhood diarrhea each year [1]. Despite improvements in case management, recent global estimates confirm that diarrheal disease remains responsible for more than one million deaths annually across all age groups, with the highest burden in children under five years of age [2]. Inequities in health-system performance also persist. A 2025 national analysis from India demonstrated wide variation in oral rehydration solution (ORS) coverage, underscoring gaps that contribute to preventable dehydration and electrolyte losses [3]. Electrolyte disturbances are among the most serious complications of acute gastroenteritis in children. Hypokalemia, sodium abnormalities, and chloride imbalances contribute to poor outcomes such as arrhythmias, ileus, and prolonged hospitalization. Recent international studies (2023–2025) emphasize that stool electrolyte composition, feeding practices, and fluid

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management play important roles in potassium and chloride balance, with rotavirus-positive cases often showing greater dehydration and more severe biochemical derangements [4-6]. Multi-country surveys from Africa and Asia also report high rates of electrolyte abnormalities in hospitalized children, reinforcing the value of routine laboratory profiling [7]. Evidence from Pakistan mirrors these findings. Single-center studies from Rawalakot and Karachi have reported frequent electrolyte disturbances in pediatric diarrhea, with hypokalemia being the most common abnormality and improving after appropriate rehydration [8]. More recent institutional data from Nowshera and other centers have confirmed that gastroenteritis is strongly linked with electrolyte shifts and renal stress, highlighting the need for proactive monitoring [9, 10]. Further Pakistani studies in 2024–2025 continue to describe specific abnormalities such as hypernatremia in children with gastroenteritis and correlations between electrolyte imbalance and clinical outcomes [11]. Despite this evidence, important gaps remain. Most datasets focus on sodium abnormalities, while chloride categories and their association with potassium status are less frequently analyzed, even though chloride physiology is closely linked with renal and gastrointestinal potassium handling. Moreover, effect sizes are rarely reported in local audits, which limits their clinical application in risk stratification. The aim is to generate evidence that can guide early testing, timely potassium replacement, and more effective fluid management strategies in similar clinical settings.

METHODS

This analytical cross-sectional study was conducted in the Pediatric Department of Qazi Hussain Ahmad Medical Complex, Nowshera, for a period of 6 months from March 2025 to August 2025. The objective was to determine the frequency of hypokalemia in children presenting with acute watery diarrhea and to assess its association with demographic, clinical, and biochemical characteristics. Ethical approval was obtained from the Institutional Ethical Review Board of Nowshera Medical College, Nowshera (Ref. No. 511/IERB/NMC), and further approval of the synopsis was granted by the Research Evaluation Unit of the College of Physicians and Surgeons Pakistan (Ref. No. CPSP/REU/PED-2022-305-6858). Written informed consent was obtained from the parents or legal guardians of all participating children and written informed consent was obtained from the parents or legal guardians of all participating children, including those under 1 year of age. The required sample was estimated for a single proportion at 95% confidence using the standard formula $n = (Z^2 \times p \times (1 - p)) / d^2$. Here, Z = 1.96 (for 95% confidence), p=0.50 (maximum variability) [11], and d is the margin of error. Substituting these values gives If d = 0.05 (5%), n=384, If d = 0.07 (7%), n=196, and If d = 0.10 (10%), n=96. A margin of error of 10% to achieve a feasible yet statistically acceptable precision during the 6-month enrollment period, while retaining the conservative choice of p=0.50. The calculated minimum sample size of 96 was further increased to 103 to allow for possible exclusions or incomplete data, which became the final sample. Children aged between 6 months and 12 years who presented with acute watery diarrhea, defined as three or more loose or watery stools within 24 hours lasting not more than 14 days, were included. Exclusion criteria comprised children with persistent diarrhea of more than 14 days, those with chronic systemic illnesses such as renal or endocrine disorders, or those who had already received intravenous potassium supplementation before presentation. Data were collected using a structured proforma, which included demographic variables (age, gender, residence, nutritional status, and immunization history), clinical features (duration and frequency of diarrhea, presence of vomiting, fever, and dehydration status), and laboratory findings (serum potassium, sodium, chloride, bicarbonate, and acid-base status). The proforma used for data collection was pilot-tested on 10 patients to establish content validity, ensuring that all relevant demographic, clinical, and laboratory variables were clearly captured without ambiguity. To maintain reliability, pediatric residents received standardized training before the study began, and all assessments were carried out under the supervision of senior consultants. This process minimized observer variation and enhanced consistency in data recording across participants. Clinical evaluation was performed by trained pediatric residents under consultant supervision, while dehydration was graded as none, some, or severe according to World Health Organization (WHO) criteria. Nutritional status was assessed by anthropometric measurements and categorized as normal, underweight, or stunted/wasted. Blood samples were collected at admission under aseptic precautions and immediately transported to the hospital laboratory. Serum electrolytes (potassium, sodium, chloride, and bicarbonate) were analyzed using a Roche Cobas c311 fully automated chemistry analyzer based on ion-selective electrode (ISE) methodology. The analyzer was calibrated daily according to manufacturer guidelines, and two levels of internal quality control sera were run with each batch to ensure precision. Samples showing hemolysis were excluded to avoid spurious potassium values. Acid-base status was determined using an automated blood gas analyzer (ABL800 FLEX, Radiometer, Denmark) on arterial or venous samples, depending on availability. Data were analyzed using SPSS version 26.0. Categorical variables were summarized as frequencies and percentages, while

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the primary outcome variable was hypokalemia, categorized as present or absent. Associations between hypokalemia and predictor variables were assessed using the Chi-square test (or Fisher's exact test where required), and a p-value <0.05 was considered statistically significant. For significant associations, the effect size was calculated using Cramér's V to quantify the strength of the relationship.

RESULTS

Out of the 103 children included in the study, the majority (55.3%) were between 1 and 5 years of age, followed by infants below 1 year (31.1%), while only 13.6% were older than 5 years. Males represented 57.3% of the cohort, giving a male-to-female ratio of approximately 1.3:1. Rural residents constituted a higher proportion (62.1%) compared to urban children (37.9%). Nutritional assessment revealed that 41.7% of children had normal growth, whereas 32.0% were underweight and 26.2% were classified as stunted or wasted. Regarding immunization status, 65.0% of the children were fully immunized, while 35.0% had either an incomplete or no vaccination history (Table 1).

Table 1: Demographic Characteristics of Children with Acute Watery Diarrhea (n=103)

Variables	Category	Frequency (%)
Age Group	<1 Year	32 (31.1%)
	1-5 Years	57 (55.3%)
	>5 Years	14 (13.6%)
Gender	Male	59 (57.3%)
	Female	44 (42.7%)
Residence	Urban	39 (37.9%)
	Rural	64 (62.1%)
Nutritional Status	Normal	43 (41.7%)
	Underweight	33 (32.0%)
	Stunted/Wasted	27 (26.2%)
Immunization Status	Complete	67 (65.0%)
	Partial/None	36 (35.0%)

Among the 103 children, nearly half (47.6%) had diarrhea lasting 3–7 days, while 38.8% experienced symptoms for less than 3 days, and 13.6% had prolonged illness beyond 7 days. The majority (56.3%) passed stools 5–10 times per day, with 22.3% suffering from severe diarrhea (>10 times daily). Vomiting was reported in 63.1% of cases, and fever was noted in just over half of the children (52.4%). Dehydration assessment showed that 60.2% of children had some dehydration, 25.2% presented with severe dehydration, while only 14.6% had no signs of dehydration (Table 2).

Table 2: Clinical Characteristics of Children with Acute Watery Diarrhea (n=103)

Variables	Category	Frequency (%)
Duration of Diarrhea	<3 Days	40 (38.8%)
	3-7 Days	49 (47.6%)
	>7 Days	14 (13.6%)
Stool Frequency/Day	Mild (<5)	22 (21.4%)
	Moderate (5-10)	58 (56.3%)
	Severe (>10)	23 (22.3%)
Vomiting	Present	65 (63.1%)
	Absent	38 (36.9%)
Fever	Present	54 (52.4%)
	Absent	49 (47.6%)
Dehydration Status	None	15 (14.6%)
	Some	62 (60.2%)
	Severe	26 (25.2%)

More than half of the children (58.3%) demonstrated hypokalemia of varying severity, while only 41.7% had normal potassium levels. Hyponatremia was seen in one-fifth of the cohort (20.4%), with hypernatremia affecting 8.7%, whereas the majority (70.9%) maintained normal sodium values. Chloride levels showed a similar pattern, with 68.9% within the normal range, 21.4% below, and 9.7% above the reference interval. Bicarbonate was normal in 62.1% of cases, but almost one-third (32.0%) exhibited reduced levels suggestive of acidosis, while 5.8% had elevated values (Table 3).

Table 3: Biochemical Characteristics of Children with Acute Watery Diarrhea (n=103)

Variables	Category	Frequency (%)
Serum Potassium	Normal (>3.5 mmol/L)	43 (41.7%)
	Mild (3.0-3.4 mmol/L)	24 (23.3%)
	Moderate (2.5-2.9)	15 (14.6%)
	Severe (<2.5)	21 (20.4%)
Serum Sodium	Normal (135-145)	73 (70.9%)
	Hyponatremia (<135)	21 (20.4%)
	Hypernatremia (>145)	9 (8.7%)
Serum Chloride	Normal (98-107)	71 (68.9%)
	Hypochloremia (<98)	22 (21.4%)
	Hyperchloremia (>107)	10 (9.7%)
Serum Bicarbonate	Normal (22-28)	64 (62.1%)
	Low (<22)	33 (32.0%)
	High (>28)	6 (5.8%)

In the present study, hypokalemia was observed across all demographic and clinical categories, but most comparisons did not reach statistical significance. Row percentages have been included in study to aid interpretation. Younger children under one year (68.8%) and those above five years (71.4%) showed a higher prevalence compared to the 1–5-year age group (49.1%), although the association between age and hypokalemia

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was not significant (χ^2 = 4.40, p=0.111). Similarly, gender did not influence distribution, with comparable rates among females (61.4%) and males (55.9%) (χ^2 = 0.31, p=0.580). Nutritional status showed a trend toward higher hypokalemia in children with normal growth (67.4%) compared to underweight (51.5%) and stunted/wasted children (51.9%), yet this difference was also not statistically significant (χ^2 = 2.56, p=0.277). Duration of diarrhea and dehydration status followed expected patterns, with hypokalemia more frequent in prolonged illness and severe dehydration, but the results again did not achieve significance (p=0.451 and p=0.241, respectively). Among biochemical parameters, serum sodium and bicarbonate levels were not significantly associated with hypokalemia. Children with hypernatremia (77.8%) tended to have more hypokalemia than those with normal (58.9%) or low sodium (47.6%), but this difference was not statistically significant (χ^2 = 2.40, p=0.301). Likewise, bicarbonate levels did not demonstrate a meaningful pattern, with hypokalemia occurring in 62.5% of those with normal, 51.5% with low, and 50.0% with high bicarbonate levels (χ^2 = 1.26, p=0.533). Acid-base status approached significance (χ^2 = 5.43, p=0.066), with hypokalemia more frequent in children with normal status (68.4%) compared to those with metabolic acidosis (45.7%) or alkalosis (45.5%). The ony statistically significant association was found with serum chloride (χ^2 = 6.66, df = 2, p=0.036, Cramér's V = 0.25), where hypochloremic children demonstrated the highest frequency of hypokalemia (77.3%), compared to 56.3% in those with normal chloride and just 30.0% in hyperchloremic children. This moderate effect size highlights chloride imbalance as an important determinant of potassium depletion in children with acute watery diarrhea (Table 4).

Table 5: Association of Hypokalemia with Demographic, Clinical, and Biochemical Variables (n=103)

Variables	Categories	Hypokalemia Present, n (%)	Hypokalemia Absent, n (%)	χ^2 (df), p-Value	Cramér's V
Age Group	<1 Year	22 (68.8%)	10 (31.2%)	4.40 (2), 0.111	-
	1-5 Years	28 (49.1%)	29 (50.9%)		
	>5 Years	10 (71.4%)	4 (28.6%)		
Gender	Male	33 (55.9%)	26 (44.1%)	0.31 (1), 0.580	-
	Female	27 (61.4%)	17 (38.6%)		
Nutritional Status	Normal	29 (67.4%)	14 (32.6%)	2.56 (2), 0.277	-
	Underweight	17 (51.5%)	16 (48.5%)		
	Stunted/Wasted	14 (51.9%)	13 (48.1%)		
Duration of Diarrhea	<3 Days	24 (60.0%)	16 (40.0%)	1.59 (2), 0.451	-
	3-7 Days	30 (61.2%)	19 (38.8%)		
	>7 Days	6 (42.9%)	8 (57.1%)		
Dehydration Status	None	10 (66.7%)	5 (33.3%)	2.85 (2), 0.241	-
	Some	32 (51.6%)	30 (48.4%)		
	Severe	18 (69.2%)	8 (30.8%)		
Serum Sodium	Normal	43 (58.9%)	30 (41.1%)	2.40 (2), 0.301	-
	Hyponatremia	10 (47.6%)	11 (52.4%)		
	Hypernatremia	7 (77.8%)	2 (22.2%)		
Serum Chloride	Normal	40 (56.3%)	31 (43.7%)	6.66 (2), 0.036	0.25
	Hypochloremia	17 (77.3%)	5 (22.7%)		
	Hyperchloremia	3 (30.0%)	7 (70.0%)		
Serum Bicarbonate	Normal	40 (62.5%)	24 (37.5%)	1.26 (2), 0.533	-
	Low	17 (51.5%)	16 (48.5%)		
	High	3 (50.0%)	3 (50.0%)		
Acid-Base Status	Normal	39 (68.4%)	18 (31.6%)	5.43 (2), 0.066	-
	Metabolic Acidosis	16 (45.7%)	19 (54.3%)		
	Metabolic Alkalosis	5 (45.5%)	6 (54.5%)		

Chi-square test applied. p<0.05 is considered statistically significant.

The clustered bar chart illustrates the distribution of hypokalemia according to serum chloride categories. Hypokalemia was most frequent among children with hypochloremia (77.3%), moderate among those with normal chloride (56.3%), and least frequent in hyperchloremic children (30.0%) (Figure 1).

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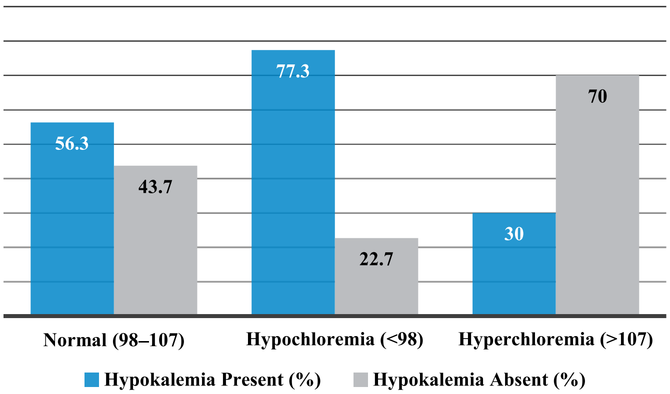

Figure 1: Association of Serum Chloride Levels with Hypokalemia in Children with Acute Watery Diarrhea (n=103)

DISCUSSIONS

This study found that hypokalemia was common in children with acute watery diarrhea (58.3%) and that potassium status varied significantly across serum-chloride categories: hypokalemia was most frequent with hypochloremia (77.3%) and least frequent with hyperchloremia (30.0%), with a moderate effect size (Cramér's V = 0.25). No statistically significant associations were observed with age, sex, nutritional status, duration of diarrhea, dehydration category, sodium, bicarbonate, or acid–base grouping. Findings on the overall burden of hypokalemia are broadly consistent with recent pediatric literature. Nasrin et al. 2024 reported hypokalemia in about 40% of children with acute diarrhea, confirming that potassium loss is a frequent complication [12]. The higher proportion in this study may reflect the wider age range and hospital-based sampling. In a tertiary African cohort, Eke et al. 2020 documented common electrolyte derangements with hypokalemia linked to mortality, evidence that underscores the clinical relevance of early potassium assessment and correction in settings like the one studied in our population [13]. Similarly, multi-centre data in southern Africa by Kinasha et al. 2025 associated electrolyte abnormalities with worse outcomes in children hospitalized for severe gastroenteritis, reinforcing the importance of routine electrolyte panels at admission [14]. More recent pediatric studies further reinforce the role of chloride imbalance in acute gastroenteritis. Khan et al. 2025 conducted a study in children aged 6 months to 3 years admitted with acute gastroenteritis at MTI DHQ Hospital, Dera Ismail Khan, Pakistan, and found that serum chloride levels were significantly elevated in children with more severe dehydration alongside potassium and sodium abnormalities [15]. The chlorid potassium signal observed here is physiologically coherent and mirrors contemporary reviews. Zaki and Shanbag describe how diarrheal bicarbonate loss typically produces normal anion-gap (hyperchloremic) metabolic acidosis, whereas chloride depletion (e.g., with vomiting or mixed fluid losses) favors metabolic alkalosis with renal potassium wasting [16]. Zieg et al. likewise emphasize the tight coupling of chloride and potassium handling in the gut and kidney [17]. Taken together, these sources explain why this study saw the highest hypokalemia frequency in hypochloremia and the lowest in hyperchloremia: chloride deficits promote kaliuresis, while hyperchloremia often accompanies acidosis without the same drive to renal potassium loss. The absence of significant associations between hypokalemia and bedside severity markers (dehydration grade, stool frequency, fever) accords with pediatric emergency observations that biochemical risk may be partly decoupled from clinical scores after early oral or intravenous rehydration. In a seasonal comparison, Saidian et al. found similar proportions of dehydration, hypernatremia, and hypokalemia across pre- and post-pandemic periods despite large shifts in admissions, an observation that helps contextualize why severity metrics did not map neatly to potassium status in this study [18]. Sodium and acid–base results also align with current syntheses. Zieg et al. and Alharbi et al. note that dysnatremias in pediatric gastroenteritis arise through mixed mechanisms (pathogen-specific stool electrolyte profiles, ORS composition, IV fluid type, and concurrent vomiting), which can obscure direct pairwise links with hypokalemia in cross-sectional snapshots such as this one [17, 19]. Likewise, trends without statistical significance for bicarbonate and categorical acid–base status in this study are unsurprising given timing effects (sampling after partial resuscitation) and the lower resolution of broad clinical categories compared with blood-gas-based classification. Regional evidence supports the local relevance of routine electrolyte testing. In Pakistani hospital cohorts, Ali et al. reported substantial electrolyte derangements with hypokalemia among children with acute malnutrition and diarrhea [20], and Chand et al. 2024 found electrolyte abnormalities in more than 90% of children with severe acute malnutrition, including hypokalemia in roughly 70% [21]. These reports strengthen the case concordant with this study's results for early electrolyte measurement (including chloride) and prompt potassium correction at admission. The strength of this study was a clear, statistically supported link between potassium status and chloride categories in AWD, indicating that chloride measurement can help flag children at the highest risk of hypokalemia even when standard bedside severity indicators and sodium or bicarbonate categories are unrevealing. Clinically, the results support early electrolyte testing (with attention to chloride), timely potassium replacement, and fluid strategies that avoid exacerbating chloride or potassium

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derangements. Future work should incorporate blood-gas analysis and time-stamped sampling before and after fluids, and, where feasible, pathogen testing, to sharpen causal inference and guide protocolized correction strategies.

CONCLUSIONS

Hypokalemia was frequent among children with acute watery diarrhea. The only factor that showed a statistically significant association with hypokalemia was serum chloride, with the highest risk with hypochloremia and lowest with hyperchloremia, while age, sex, nutritional status, illness duration, dehydration, sodium, bicarbonate, and acid-base status were not significantly related. Clinically, early electrolyte testing (including chloride), timely potassium correction, and fluid plans that avoid worsening chloride or potassium imbalance should be routine. Future studies should incorporate blood-gas-based assessment and time-stamped sampling around fluid therapy to refine management.

Authors Contribution

Conceptualization:
Methodology: TA, KA, IK, AI, SSAT, SJS
Formal analysis: KA, AI
Writing review and editing: TA, KA, AI, SSAT, SJS

All authors have read and agreed to the published version of the manuscript

Conflicts of Interest

All the authors declare no conflict of interest.

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