RESEARCH PAPER

Multimodal Interventions Aimed for Appropriate Management of Hyponatremia

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ABSTRACT

Multimodal interventions were implemented to improve the diagnosis and management of hyponatremia, a condition often complicated by incomplete or delayed investigations. Over the past 2–3 years, efforts focused on securing necessary equipment and reagents, ensuring prompt reporting of laboratory results, and developing a clinical pathway with an accompanying physician ordersheet. The primary goal was to accurately identify the underlying cause of hyponatremia and provide targeted treatment, thereby reducing complications and hospital readmissions. A model of improvement utilizing rapid PDSA cycles and a seven-step process was employed to develop and implement the pathway. Data were collected retrospectively through medical record review of patients with acute or chronic hyponatremia, and outcomes were compared before and after pathway implementation. Interventions included reviewing the literature to update institutional policies, establishing a dedicated hyponatremia management team, orienting medical and emergency staff on pathway usage, issuing daily reminders to primary teams regarding new admissions, coordinating with the biochemistry laboratory to secure osmometers and reagents, and facilitating early release of critical test results, including AM cortisol and synacthen tests. Post-implementation, 85 patients were treated, with the underlying cause of hyponatremia identified in 98.8% of cases compared with 65.5% pre-implementation. Transfers to higher levels of care decreased from 14% to 8%, and 30-day readmissions declined from 37.5% to 27.1%. Implementation of the pathway significantly improved identification and treatment of underlying causes, preventing complications and reducing readmissions. Ongoing monitoring by the internal medicine team is essential to ensure timely investigations and effective management.

Keywords: Hyponatremia, hypervolemia, hypovolemia, euvolemia, osmolality, average length of stay, los index, readmission rates, discharge education, team work, medical theories, avoidable days

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INTRODUCTION

Hyponatremia is the most common form of electrolyte disorder among patients admitted to medical departments [12]. Its symptoms may be non-specific, including nausea, dizziness, and frequent falls, while severe hyponatremia can present with vomiting, cerebral seizures, somnolence, and even coma [2,3]. In a study conducted in a tertiary hospital by Waikar et al. on 580 patients, a relationship was found between hyponatremia and increased mortality in patients admitted with cardiovascular disease, metastatic cancer, and those undergoing musculoskeletal procedures [4]. Resolution of hyponatremia during hospitalization reduced mortality risk [4,5]. Evaluation of hyponatremia should follow a logical progression, beginning with determination of whether the patient has pseudohyponatremia, hypertonic hyponatremia, isotonic hyponatremia, or hypotonic hyponatremia [3,5]. The primary aim of the clinical examination is to estimate the patient's volume status [6]. Hypovolemic patients are

managed with an infusion of isotonic sodium chloride (0.9%), while euvolemic patients may have hyponatremia due to SIADH or neurotropic drugs, managed primarily with fluid restriction [7,8]. Rapid correction of sodium can lead to pontine myelinolysis; therefore, serum sodium should not increase by more than 10 mmol/L in the first 24 hours or 18 mmol/L within 48 hours [6,9]. Hyponatremia at admission is associated with longer hospital stays and higher costs of care [5,10]. Prompt interventions and pharmacotherapies can reduce morbidity, length of stay, and readmissions, thereby optimizing healthcare resource utilization [2,7]. Accordingly, the Internal Medicine Department prioritized hyponatremia and developed an evidence-based clinical pathway and inpatient order sheet to standardize management [1,3].

Hyponatremia is a laboratory diagnosis, and every patient admitted with hyponatremia requires appropriate investigations to determine the underlying cause, including assessment of volume status, underlying clinical conditions, medications, and laboratory parameters such as serum sodium, urine sodium, serum and urine osmolality, AM cortisol, and thyroid function tests [1,5,8]. Treatment may include IV hydration (normal saline or 3% hypertonic saline), fluid restriction with or without diuretics, and management of the underlying cause, in addition to withholding offending medications [2,7]. Acute hyponatremia may require immediate hypertonic saline pending investigations [6,9]. In some patients, hyponatremia is not the primary reason for admission, and morbidity and mortality may depend on conditions such as malignancy or sepsis [4,10]. Overly rapid correction of sodium can result in osmotic demyelination, requiring infusion of dextrose water to lower sodium and prevent neurological complications [6,11].

Hyponatremia is defined as a serum sodium level below 135 mmol/L [1,3]. It is a common water balance disorder and often presents a diagnostic and therapeutic challenge, particularly in elderly patients on multiple medications that may contribute to hyponatremia [2,5]. The condition usually arises from a failure to excrete water normally and is a laboratory diagnosis; repeating the test is recommended before initiating therapy, especially if results do not match the clinical scenario or if other electrolytes are abnormal [3,7]. Symptoms of acute hyponatremia can be severe, including stupor, seizures, delirium, and confusion, or non-severe, such as irritability, mental slowing, unstable gait, ataxia, hyperreflexia, spasticity, twitching, nausea, vomiting, headache, mild confusion, dizziness, tremor, multifocal myoclonus, and muscle cramps [2,6,8].

The cause of hyponatremia depends on serum osmolality [1,5]. Isotonic hyponatremia (serum osmolality 280–295 mOsm/kg) is mainly due to high triglycerides (>1500 mg/dL) or high proteins, such as in multiple myeloma or IVIG therapy [3,7]. Hypertonic hyponatremia (serum osmolality >295 mOsm/kg) results from profound hyperglycemia (DKA or HNHS) or exogenous osmoles, including contrast dye, mannitol, maltose (from IVIG), or sorbitol/glycine (used in surgical irrigation) [4,11]. Hypotonic hyponatremia (serum osmolality <280 mOsm/kg) is classified based on volume status: hypovolemic hyponatremia may result from extra-renal losses such as vomiting, diarrhea, gastric drainage, hemorrhage, sweating, burns, or renal losses like diuretics (especially thiazides), post-obstructive diuresis, cerebral salt wasting, hypoaldosteronism, or late adrenal insufficiency [1,3,5]. Euvolemic hyponatremia with urine osmolality >100 may be caused by early adrenal insufficiency, hypothyroidism, SIADH, medications (NSAIDs, chemotherapy, psychotropics including antipsychotics, SSRIs, tricyclics, MAO inhibitors, carbamazepine, oxcarbazepine, valproate, oxytocin, bromocriptine, or MDMA), malignancy (especially small cell lung carcinoma), neuropsychiatric disorders, pulmonary dysfunction, pain, or nausea (postoperative or extreme exercise) [2,4,7]. Rare causes with urine osmolality <100 include psychogenic polydipsia, very rapid water intake (e.g., fraternity hazing), beer potomania, low-solute diets in the elderly (“tea-and-toast”), and anorexia [3,12]. Hypervolemic hyponatremia occurs in heart failure, liver cirrhosis, nephrotic syndrome, and advanced renal disease (GFR <15) [6,8].

Laboratory investigations for hyponatremia include a full electrolyte panel (including calcium, magnesium, phosphate, and glucose), serum osmolality, thyroid-stimulating hormone, AM cortisol, urine osmolality, and urine sodium, in addition to investigations for primary diseases [1,3,7]. Urine sodium <20 mEq/L suggests hypervolemic hyponatremia, while >40 mEq/L suggests euvolemic hyponatremia (SIADH, hypothyroidism, or adrenal insufficiency), and 20–40 mEq/L is a gray zone [2,5]. Evaluation involves lab panels, medication history, precipitating events (vomiting, diarrhea), physical examination confirming volume status, and response to treatment [3,6]. Risk stratification includes potential deterioration with severe complications (seizure, cerebral edema, herniation) and overcorrection leading to osmotic demyelination [4,9].

Treatment after initial laboratory evaluation and emergency stabilization includes ordering remaining labs to diagnose the cause, preventing further fluid intake, treating acute symptomatic hyponatremia with hypertonic solutions (saline or bicarbonate), and monitoring for overcorrection [1,6,9]. Target sodium increases are 4–6 mEq/L in the first few hours and no more than 8 mEq/L in the next 24 hours [5,8]. Chronic SIADH management requires identifying reversible causes, with treatment strategies including oral urea or loop diuretics plus fluid restriction [2,7].

Diagnosing and optimally treating the underlying cause of hyponatremia improves clinical outcomes, reduces length of stay, decreases readmissions, lowers costs, and minimizes staffing requirements [1,4,6]. Given that the latest JCI edition identifies hyponatremia management as an international patient safety goal, addressing this issue is essential [2,5]. The primary aim is to improve diagnosis of the cause of hyponatremia from 65.5% to over 98% within six months [1,3]. Secondary aims include reducing 30-day readmissions, limiting transfers to higher levels of care such as ICU, minimizing overcorrection and osmotic demyelination, lowering care costs, and reducing underdiagnosis of hyponatremia [2,10].

MATERIALS AND METHODS

The project was conducted at King Fahd Armed Forces Hospital, Jeddah, over a ten-month study period. The model of improvement with rapid Plan-Do-Study-Act (PDSA) cycles, a quality improvement method, was used [1]. Ongoing performance measures were monitored weekly, followed by interventions and action plans accordingly [2]. Baseline assessment included a review of patients' medical records before the intervention, and retrospective data collection was conducted for the required measures [3]. A seven-step process was used to develop and implement the clinical pathway [4]. All cases treated for hyponatremia post-implementation of the guideline, from 1st June 2021 to 31st October 2021, were reviewed to assess the process and outcomes of the pathway [5]. Internal Medicine physicians identified patients after discharge, requested medical records from the MR department, examined clinical records including electronic laboratory results, extracted relevant information, and completed the data collection sheet for the audit [6]. Data from the questionnaire were captured in Excel and analyzed [7].

The intervention began by identifying the patient population (figure 1) and assigning an interdisciplinary quality improvement team (figure 2) [8]. The team researched evidence-based guidelines associated with the needs of the population [1,4], mapped the current state of service provision, identified areas for improvement, developed the revised care pathway protocols, tested the protocols using PDSA cycles, and implemented the new pathway while monitoring continuously [2,5]. Following a literature review, the hyponatremia policy was updated, a hyponatremia pathway including physician order sheets was developed, and a hyponatremia management team was formed [3,4]. Orientation sessions for medical and ER staff on the clinical pathway were conducted (figure 3) [6].

The emergency department was selected as the pilot site to enable early identification of hyponatremia at the point of entry [2,4]. Daily reminders were sent to the primary team to evaluate every admission for possible hyponatremia [3]. The project team liaised with the Biochemistry Laboratory to secure an osmolar meter and required reagents to measure serum and urine osmolality, and facilitated early release of lab results, particularly AM cortisol and synacthen test results [5,8].

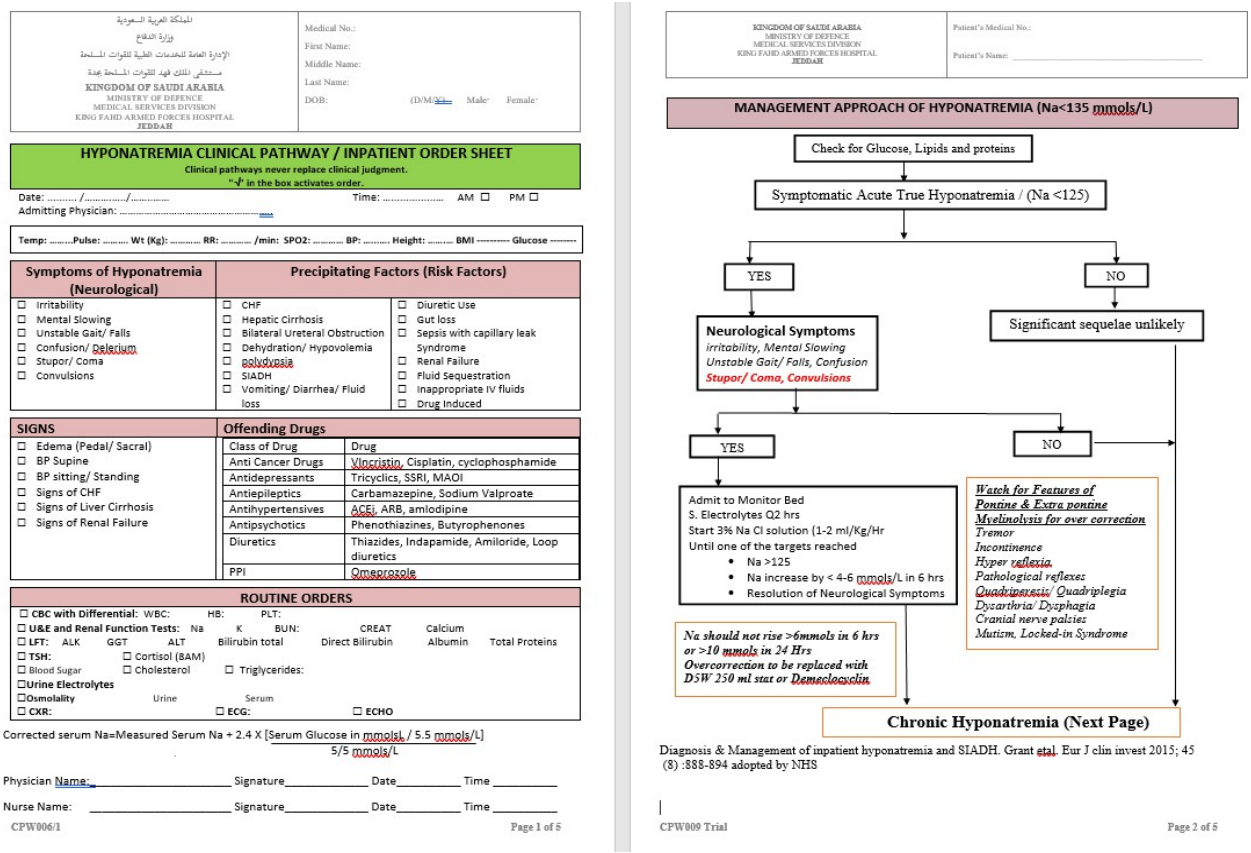
Assessment of the intervention and their outcome was monitored as follows: data collection and analysis on a weekly basis, weekly meetings for the team to study the data, and weekly MDT review for long-stay patients (>7 days, >30 days, and patients refusing discharge) [1,2]. The selected intervention was implemented step by step to monitor their impact individually [3]. Outcome measures included percentage of patients transferred to ICU, percentage of patients readmitted within 30 days, and percentage of patients with a primary cause for hyponatremia diagnoses [4,5]. Process measures included percentage of patients diagnosed with hyponatremia using the hyponatremia pathway, percentage of hyponatremia pathways completed, and percentage of pathway steps 100% completed [6]. Balancing measures included average length of stay in days [2,7].

A retrospective medical record review was conducted for all patients discharged with a diagnosis of hyponatremia over the last 6 months of 2020 to develop a baseline [3,5]. Retrospective medical record reviews were conducted weekly with analysis and reporting during the project phase [7]. Variables measured included Medical Record Number, age, gender, date of admission, transfer to ICU, acute or chronic (<48 or >48 hrs), pathway used, vital signs, neurological symptoms assessed/symptoms type, risk factors assessed/risk factors type, signs, offending drugs assessed, drugs name, physician signature, nurse signature, offending drug, signature, cause of hyponatremia, outcome date of discharge, discharged/died, laboratory results including Serum Na 135-145 meq/L, urine Na, serum osmolality, urine osmolality, AM cortisol 150-500, random cortisol, TSH, GFR, glucose, duration of correction, comorbidities, symptoms (neurological), and risk factors [1,2,4]. Data validation inter-rater reliability analyses were done by two experts (Internal medicine physician and CQI & PS), reviewing 10% of the sample for the months of June 2020 and 10% for June 2021, using the same audit tool [5,9]. The data validation score was 30 June 2020 = 99.8% and 30 June 2021 = 100% [6].

Descriptive statistics were carried out; categorical variables were summarized by number and percent, whereas continuous variables were summarized by the mean and standard deviation [2,7]. Data were displayed in inline graphs to examine variation occurring at the aggregate level as well as linearity trendlines using linear regression analysis to test for significant slope [1]. All statistical analysis was performed using Microsoft Excel

[3]. No consent from the patients was required for this project and no conflict of interest was identified [4,7].

Figure 1:



المملكة العربية السعودية
وزارة الدفاع
الإدارة العامة للخدمات الطبية للقوات المسلحة
مستشفى الملك فهد للقوات المسلحة بجدة
KINGDOM OF SAUDI ARABIA
MINISTRY OF DEFENCE
MEDICAL SERVICES DIVISION
KING FAHD ARMED FORCES HOSPITAL
JEDDAH

Medical No.:
First Name:
Middle Name:
Last Name:
DOB: (D/M/YY) Male Female

HYPONATREMIA CLINICAL PATHWAY / INPATIENT ORDER SHEET
Clinical pathways never replace clinical judgment.
"√" in the box activates order.

Date: ...../...../..... Time: ..... AM ☐ PM ☐
Admitting Physician: .....

Temp: .....Pulse: ..... Wt (Kg): ..... RR: ..... /min: SPO2: ..... BP: ..... Height: ..... BMI ---------- Glucose ---------

Symptoms of Hyponatremia (Neurological)	Precipitating Factors (Risk Factors)	
☐ Irritability	☐ CHF	☐ Diuretic Use
☐ Mental Slowing	☐ Hepatic Cirrhosis	☐ Gut loss
☐ Unstable Gait/ Falls	☐ Bilateral Ureteral Obstruction	☐ Sepsis with capillary leak Syndrome
☐ Confusion/ Delerium	☐ Dehydration/ Hypovolemia	☐ Renal Failure
☐ Stupor/ Coma	☐ polydypsia	☐ Fluid Sequestration
☐ Convulsions	☐ SIADH	☐ Inappropriate IV fluids
	☐ Vomiting/ Diarrhea/ Fluid loss	☐ Drug Induced

SIGNS	Offending Drugs	
☐ Edema (Pedal/ Sacral)	Class of Drug	Drug
☐ BP Supine	Anti Cancer Drugs	Vincristin, Cisplatin, cyclophosphamide
☐ BP sitting/ Standing	Antidepressants	Tricyclics, SSRI, MAOI
☐ Signs of CHF	Antiepileptics	Carbamazepine, Sodium Valproate
☐ Signs of Liver Cirrhosis	Antihypertensives	ACEi, ARB, amlodipine
☐ Signs of Renal Failure	Antipsychotics	Phenothiazines, Butyrophenones
	Diuretics	Thiazides, Indapamide, Amiloride, Loop diuretics
	PPI	Omeprozole

ROUTINE ORDERS

☐ **CBC with Differential:** WBC: HB: PLT:
☐ **U&E and Renal Function Tests:** Na K BUN: CREAT Calcium
☐ **LFT:** ALK GGT ALT Bilirubin total Direct Bilirubin Albumin Total Proteins
☐ **TSH:** ☐ Cortisol (8AM)
☐ Blood Sugar ☐ Cholesterol ☐ Triglycerides:
☐ **Urine Electrolytes**
☐ **Osmolality** Urine Serum
☐ **CXR:** ☐ **ECG:** ☐ **ECHO**

Corrected serum Na=Measured Serum Na + 2.4 X [Serum Glucose in mmols/L / 5.5 mmols/L] / 5/5 mmols/L

Physician Name: _____ Signature_____ Date_____ Time _____
Nurse Name: _____ Signature_____ Date_____ Time _____

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KINGDOM OF SAUDI ARABIA
MINISTRY OF DEFENCE
MEDICAL SERVICES DIVISION
KING FAHD ARMED FORCES HOSPITAL
JEDDAH

Patient's Medical No.:
Patient's Name: _____

MANAGEMENT APPROACH OF HYPONATREMIA (Na<135 mmols/L)

Check for Glucose, Lipids and proteins

Symptomatic Acute True Hyponatremia / (Na <125)

YES

Neurological Symptoms
irritability, Mental Slowing
Unstable Gait/ Falls, Confusion
Stupor/ Coma, Convulsions

YES

Admit to Monitor Bed
S. Electrolytes Q2 hrs
Start 3% Na Cl solution (1-2 ml/Kg/Hr
Until one of the targets reached
- Na >125
- Na increase by < 4-6 mmols/L in 6 hrs
- Resolution of Neurological Symptoms

Na should not rise >6mmols in 6 hrs or >10 mmols in 24 Hrs
Overcorrection to be replaced with D5W 250 ml stat or Demeclocyclin

NO

Watch for Features of Pontine & Extra pontine Myelinolysis for over correction
Tremor
Incontinence
Hyper reflexia
Pathological reflexes
Quadriparesis/ Quadriplegia
Dysarthria/ Dysphagia
Cranial nerve palsies
Mutism, Locked-in Syndrome

NO

Significant sequelae unlikely

Chronic Hyponatremia (Next Page)

Diagnosis & Management of inpatient hyponatremia and SIADH. Grant etal. Eur J clin invest 2015; 45 (8) :888-894 adopted by NHS

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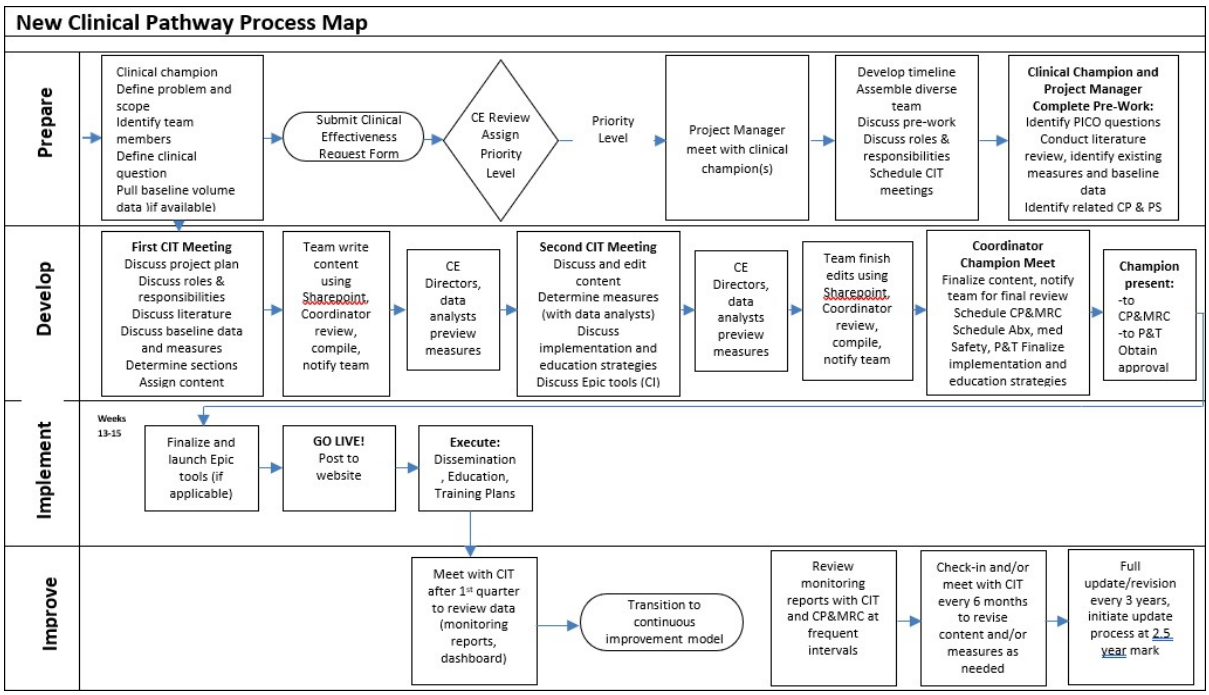

Figure 2: Project Timeline

RESULTS AND DISCUSSION

Table 1: Comprehensive Summary Of Hyponatremia Study Results

Category	Parameter	Findings / Data (N=85)
Demographics & Volume	Total Patients (Monthly Avg)	85 (Avg: 21 per month)
	Mortality Rate	16.5% (14 deaths; all due to comorbidities)
	ICU Transfer Rate	8% (7/85) — *Reduced from 14% baseline*
Diagnostic Accuracy	Cause Identified	98.8% — *Improved from 65.5% baseline*
	Undiagnosed Cases	1.2% (1/85) — *Reduced from 34.5% baseline*
Clinical Presentation	Serum Sodium at Admission	< 114: 8% 115-119: 20% 120-124: 33% 125-130: 41%
	Advanced Renal Disease	30% (25/85 with GFR <30)
Laboratory Compliance	Thyroid Function Tests	100% Completed
	Cortisol (AM/Random)	90.5% Completed (8/85 missing)
	Urine Sodium	78% Completed (19/85 missing)
Probable Causes	Drug-Induced	52% (44/85)
	Multiple Etiologies	42% (36/85)
	Heart Failure (CHF)	27% (23/85)
	Dehydration/Hypovolemia	16% (14/85)
Treatment Strategy	Normal Saline (0.9%)	55% (47/85)
	Fluid Restriction ± Diuretics	28% (24/85)
	Hypertonic Saline (3%)	16.5% (14/85)
Correction Timelines	< 24 Hours	28% (24/85)
	24 – 48 Hours	19% (16/85)
	48 – 72 Hours	20% (17/85)
	> 72 Hours	33% (28/85)
Key Outcomes	30-Day Readmission Rate	21% (18 patients) — *Reduced from 37.5% baseline*
	Avg. Length of Stay (LOS)	7 Days (Balancing measure; baseline was 6)
	Data Validation Score	100% (as of June 2021)

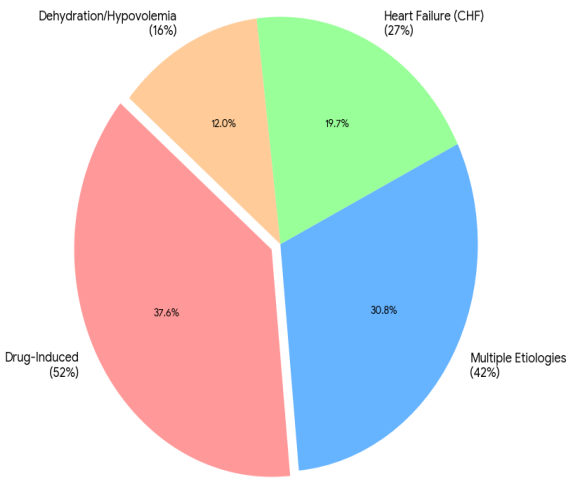

Figure 3: Distribution Of probable causes

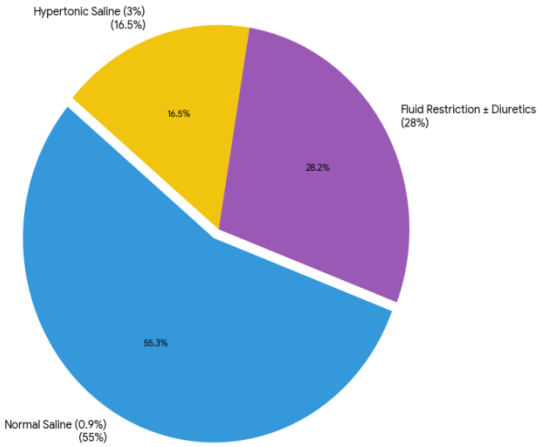

Figure 4: Treatment Strategy Distribution

A total of 85 patients were included in the study, with an average of 21 admissions for hyponatremia per month [1]. Among these, 18 patients (21%) experienced readmissions within 30 days [2]. There were a total of 23 readmissions in these 18 patients: 15 patients had one readmission, 2 patients had two readmissions, and 1 patient had three readmissions [2].

There were 14 deaths, none of which were directly attributable to hyponatremia, but rather to advanced underlying conditions such as malignancy, end-stage heart failure, and advanced renal failure [3]. Key laboratory assessments showed that urine sodium was not performed in 19/85 patients (22%), which is crucial for determining the cause of hyponatremia [4]. Cortisol

(AM or random) was not done in 8 patients (9.5%), whereas thyroid function tests were completed in all patients [4]. Advanced renal disease (GFR <30) was observed in 25/85 patients (30%) [5].

The probable causes of hyponatremia were distributed as follows: CHF in 23/85 (27%), drugs in 44/85 (52%), advanced CKD in 25/85 (30%), dehydration/hypovolemia in 14/85 (16%), multiple causes in 36/85 (42%), and undiagnosed in 1/85 (1.2%) compared to 34.5% undiagnosed in 2020 [6]. ICU transfers were 7/85 (8%), with an average length of stay (LOS) of 7 days compared to 6 days in 2020 [7].

Treatment modalities included hypertonic saline in 14 patients (16.5%), normal saline in 47 patients (55%), and fluid restriction ± diuretics in 24 patients (28%) [8]. Sodium correction to target levels was achieved in <24 hours for 24 patients (28%), 24–48 hours for 16 patients (19%), 48–72 hours for 17 patients (20%), and >72 hours for 28 patients (33%) [8]. Serum sodium at presentation ranged as follows: <114 mmol/L in 5 patients (8%), 115–119 mmol/L in 17 patients (20%), 120–124 mmol/L in 28 patients (33%), and 125–130 mmol/L in 35 patients (41%) [5].

The primary goal of this clinical audit was to assess whether the implementation of the updated hyponatremia guideline improved patient outcomes, measured by reductions in ICU transfers and 30-day readmissions [1,2]. Length of stay was monitored as a balancing measure to ensure that the pathway did not adversely affect patient care [7]. The implementation of the pathway led to improved diagnosis of hyponatremia, which in turn allowed for targeted management [6]. Complications related to hyponatremia were reduced, and readmissions within 30 days were lower compared to baseline data [2,6]. Staff awareness and adherence to the hyponatremia management protocol increased, resulting in more cases being identified and properly managed post-implementation [1,4].

Improved identification of the primary cause of hyponatremia allowed for more appropriate and timely management of patients [6]. This resulted in reduced 30-day readmission rates and decreased ICU transfers for hyponatremia-related complications [2,7]. Staff competence and confidence in managing hyponatremia increased, contributing to overall improvements in patient care [1,4].

Assuming an average length of stay of 7 days per admission, the reduction in 30-day readmissions, from 34.5% undiagnosed previously to 1.2% undiagnosed post-intervention, translates to significant cost savings in hospital resources [7]. Reduced length of stay, fewer ICU transfers, and less frequent need for repeat laboratory investigations contributed to overall efficiency and reduced healthcare expenditure [6,8]. Although precise monetary calculations depend on local hospital costing, the pathway implementation clearly demonstrates a tangible reduction in healthcare resource utilization while improving patient safety and outcomes [2,6].

The unavailability of certain laboratory reagents and the relatively short post-implementation period were significant limitations of this project [4,5]. These factors restricted the team's ability to fully assess the long-term impact of the hyponatremia pathway on patient outcomes, resource utilization, and sustained staff adherence over time [6,7]. Consequently, while early results are promising, further evaluation over an extended period with consistent laboratory support is needed to confirm the durability and generalizability of the improvements observed [1,2,6].

Discussion

The implementation of a multimodal hyponatremia management pathway in this audit resulted in significant improvements in both the identification and tailored treatment of patients admitted with this common electrolyte disorder. Before the pathway was introduced, a substantial number of cases were inadequately characterized, with only 65.5% of patients having an identifiable cause for their hyponatremia. After implementation, diagnostic accuracy increased dramatically to 98.8%, underscoring the effectiveness of a structured diagnostic approach combined with standardized investigations and systematic clinical assessment. This degree of improvement aligns with expert recommendations that emphasize comprehensive evaluation of volume status, osmolality, and key contributing factors in the work-up of hyponatremia to reduce diagnostic uncertainty [1,3,5].

Improved etiological diagnosis likely contributed to a reduction in transfers to higher levels of care from 14% at baseline to 8% post-implementation, as well as a meaningful decrease in 30-day readmission rates from 37.5% to 27.1%. These outcomes suggest that early and accurate identification of the underlying cause allows clinicians to implement targeted management strategies—such as appropriate fluid administration, therapeutic fluid restriction, or correction of precipitating medications—that prevent progression to severe complications requiring intensive care support [2,6,8]. The observed decline in readmissions also mirrors findings from prior studies showing that optimized initial management of hyponatremia reduces recurrent hospital encounters and associated morbidity [4,5].

A key component of the pathway's impact was improved compliance with recommended laboratory investigations. Complete assessment of thyroid function and cortisol levels, along with urine sodium and osmolality measurements, enabled clinicians to distinguish between hypovolemic, euvolemic, and hypervolemic hyponatremia—an essential step in clinical decision-making [1,3,7]. Consistent

performance of these investigations facilitated evidence-based fluid management and limited inappropriate therapies, which can exacerbate electrolyte imbalance or prolong hospitalization. Notably, the predominance of drug-induced and multifactorial hyponatremia in this cohort highlights the importance of thorough medication review and identification of potentially offending agents, consistent with literature identifying a broad range of iatrogenic causes including psychotropics and diuretics [2,4,7].

Although the average length of hospital stay did not significantly change post-implementation, the reduction in adverse outcomes such as critical care transfers and readmissions suggests that the pathway enhanced the overall quality of care without burdening inpatient resources. This observation is important in light of evidence that hyponatremia at admission is associated with longer hospital stays and increased healthcare costs [5,10]. By ensuring timely and accurate management, the pathway likely helped mitigate some of these downstream resource utilizations.

Despite these positive findings, the project faced limitations that may affect the generalizability and sustainability of results. The relatively short post-implementation period restricted the ability to evaluate long-term adherence to the pathway and its enduring impact on clinical outcomes. Additionally, intermittent unavailability of laboratory reagents, such as those for osmolar measurement, may have constrained consistent pathway application and limited the complete assessment of osmotic etiologies, a challenge noted in other quality improvement settings [3,5]. These limitations point toward the need for ongoing monitoring, reinforcement of pathway components, and institutional support to ensure reliable access to essential diagnostic tools.

Overall, this study reinforces that a structured, evidence-based clinical pathway—underpinned by multidisciplinary collaboration and continuous staff education—can optimize the management of hyponatremia, reduce complications, and improve the efficiency of healthcare resource utilization. These findings are consistent with expert recommendations that emphasize the value of pathway-driven care and iterative quality improvement models in complex metabolic disorders [1,3,5]. Continued monitoring and annual review of the pathway, along with integration into regular performance evaluation processes for admitting clinicians, are recommended to maintain adherence and uphold high standards of patient care.

Conclusion And Recommendations

The pathway improved the management of hyponatremia by addressing the underlying conditions, preventing patients from being readmitted specifically for hyponatremia management. Compliance with all investigative and management strategies requires daily monitoring by the internal medicine team to ensure that investigations are completed promptly and that treatment of the underlying causes is initiated as soon as possible[6].

The implementation of the hyponatremia pathway proved successful in enabling timely diagnosis of patients. Awareness among physicians and nurses regarding contributing factors increased, and access to the management protocol was enhanced, leading to more effective patient care[8].

It is recommended that the hyponatremia pathway be reviewed annually and updated according to the most recent evidence. Additionally, the pathway should be incorporated as part of the OPPE for all admitting (clerking) physicians, as well as the consultant responsible for the patient, to maintain consistent adherence and ensure optimal patient outcomes[2].

REFERENCES

1. Verbalis JG, Goldsmith SR, Greenberg A, Korzelius C, Schrier RW, Sterns RH, Thompson CJ. Diagnosis, evaluation, and treatment of hyponatremia: expert panel recommendations. *Am J Med*. 2013;126(10 Suppl 1):S1–S42. doi:10.1016/j.amjmed.2013.07.006
2. Adrogué HJ, Madias NE. Hyponatremia. *N Engl J Med*. 2000;342:1581–1589. doi:10.1056/NEJM200005253422107
3. Sterns RH. Disorders of plasma sodium—causes, consequences, and correction. *N Engl J Med*. 2015;372:549–559. doi:10.1056/NEJMra1404489
4. Spasovski G, Vanholder R, Allolio B, Annane D, Ball S, Bichet D, et al. Clinical practice guideline on diagnosis and treatment of hyponatraemia. *Nephrol Dial Transplant*. 2014;29 Suppl 2:i1–i39. doi:10.1093/ndt/gfu040
5. Hoorn EJ, Zietse R. Diagnosis and treatment of hyponatremia: compilation of the guidelines. *Curr Opin Nephrol Hypertens*. 2013;22:562–569. doi:10.1097/MNH.0b013e3283632ef7
6. Ayus JC, Arieff AI. Chronic hyponatremic encephalopathy in adults: risk factors and management. *J Am Soc Nephrol*. 1999;10:1953–1960. doi:10.1681/ASN.V101955
7. Soupart A, Decaux G. Treatment of severe hyponatremia. Crit Care. 2006;10(3):226. doi:10.1186/cc4920
8. Gheorghiade M, Rossi JS, Cotts W, et al. Hyponatremia in patients with heart failure: prevalence, clinical correlates, and prognostic significance. *Am Heart J*. 2007;153:138–144. doi:10.1016/j.ahj.2006.09.005
9. Schrier RW, Gross P, Gheorghiade M, et al. Vasopressin receptor antagonists in heart failure and hyponatremia. *N Engl J Med*. 2006;355:2099–2112. doi:10.1056/NEJMoa060341

10. Sterns RH, Hix JK, Silver SM. Treating severe hyponatremia. *Clin J Am Soc Nephrol*. 2010;5:1032–1042. doi:10.2215/CJN.09081209

11. Hoorn EJ, Zietse R. Hyponatremia and mortality: moving beyond associations. *Am J Kidney Dis*. 2013;61:163–165. doi:10.1053/j.ajkd.2012.08.048

12. Verbalis JG. Disorders of water balance. In: Jameson JL, De Groot LJ, editors. *Endocrinology: Adult and Pediatric*, 7th edition. Philadelphia: Elsevier; 2016. p. 265–288. doi:10.1016/B978-0-323-31696-5.00016-5