



SCHOOL OF NURSING

Electrolyte Imbalance and Associated Factors among Patients in Intensive Care Units of Public Hospitals, Bahir Dar, Ethiopia.

Principal Investigator: Getu Gashaw(BSc)

A research thesis submitted to the Department of Emergency and Critical Care Nursing, School of Nursing, at St. Paul's Hospital Millennium Medical College in partial fulfillment of the requirements for the degree of master of science in Critical Care Nurse Practitioner.

August, 2024

Addis Ababa, Ethiopia

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Abstract

Introduction: Electrolytes are substances that are electrically charged and help our body do much of its work. In Ethiopian hospitals, most electrolyte test results showed a change in at least one of the electrolytes. Electrolyte imbalances in the intensive care unit interfere with the main goal of intensive care and result in adverse patient outcomes like the risk of nosocomial infection, dissatisfaction, morbidity, and mortality. Despite this, little is known about the level of electrolyte imbalance and factors associated with patients who are on intensive care in Ethiopia's context.

Objective: To assess the electrolyte imbalance and associated factors among patients in intensive care units of public hospitals in Bahir Dar, Ethiopia, in 2024.

Methods: An institution-based cross-sectional study was conducted in the Bahir Dar Public Hospital intensive care unit with 404 study participants selected using systematic random sampling. A pretested, structured questionnaire was used to collect the data. The data were collected using Kobo Toolbox, downloaded, and exported to SPSS version 26 software for analysis. Descriptive statistics were computed. Bivariable binary binlogistic regression analysis was carried out, and variables with a p-value less than 0.25 were entered into multivariable binary logistic regression analysis. Variables with a P-value less than 0.05 in the final model were considered statistically significant. The result was presented using text, tables, and graphs.

Result: 401 study participated with a response rate of 99.3%. The prevalence of electrolyte imbalance among patients in intensive care units in this study was 83.8% (95% CI: 80, 87.5). Patients who took diuretics (AOR: 4.532; 95% CI: 1.971, 10.42), Vasoactive (AOR: 5.989; 95% CI: 1.253, 28.61), normal saline (AOR: 2.956; 95% CI: 1.424, 6.137), and Ringer's lactate (AOR: 4.192; 95% CI: 1.452, 12.109) were significantly associated with electrolyte imbalance in the intensive care unit patients.

Conclusion: This study found that 83.7% patients in intensive care unit have electrolyte imbalance. Medication and fluids like diuretics, vasoactive, normal saline, and Ringer's lactate showed a statistically significant association with electrolyte imbalances in the intensive care unit patients.

Keywords: Bahir Dar, Ethiopia, electrolyte imbalance, intensive care unit.

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List of Acronyms and Abbreviations

ACEI	Angiotensin Converting Enzyme Inhibitors
AKI	Acute Kidney Injury
AOR	Adjusted Odds Ratio
BSC	Bachelor of Science
CI	Confidence Interval
COR	Crude Odds Ratio
DM	Diabetes Mellitus
ETB	Ethiopian Birr
FHCSH	Felege Hiwot Comprehensive Specialized Hospital
HF	Heart Failure
ICU	Intensive Care Unit
IU/L	International Unit Per Liter
MEQ/L	Milliequivalent Per Liter
MSC	Master of Science
NGO	Non-Governmental Organization
NOACS	Novel Oral Anticoagulants
NSAID	Non-Steroidal Anti-Inflammatory Drug
OR	Odds Ratio
SD	Standard Deviation
SPHMMC	St.Paul’S Millennium Medical College
TGCSH	Tibebe Ghion Comprehensive Specialized Hospital

1. Introduction

1.1 Background

An electrolyte imbalance occurs when certain mineral levels in the blood are either too high or too low. This imbalance can lead to various symptoms such as weakness, muscle spasms, irregular heartbeat, and more, depending on the severity and type of electrolyte affected. Electrolytes like potassium, sodium, magnesium, and calcium play crucial roles in balancing body fluids, regulating heart rhythm, and supporting nerve and muscle function(1-3) In hospitalized patients in the intensive care unit, electrolyte disturbances are common due to underlying diseases or taking specific medicines. An intensive care unit is a specialized department in a hospital or healthcare facility that provides intensive and specialized medical care to patients with severe or life-threatening illnesses and injuries. It is equipped with specialized staff, equipment, and standards to provide critical care and life support for acutely ill and injured patients. Electrolyte imbalances are among the most common clinical problems encountered in the setting of intensive care (4-6).

Electrolytes are minerals and compounds that are electrically charged and help our body do much of its work. They are involved in many essential processes in our body, such as metabolic and homeostatic functions, which include enzymatic and biochemical reactions, maintenance of cell membrane structure and function, neurotransmission , nerve signal conduction, cardiovascular function, muscle contraction, bone composition and fluid, and acid regulation (7).

Electrolyte imbalances are common in both general and ICU settings. In a general population, the magnitude of electrolyte disturbance can vary, with studies reporting prevalence rates of around 44.1% to 86.1% among study participants (8, 9). In the ICU, fluid and electrolyte disturbances are among the most common clinical problems encountered, and they can lead to fatal consequences (6). Specific electrolytes such as sodium, potassium, calcium, magnesium, and chloride are commonly encountered and can be abnormal in critically ill patients (10). The most serious and common electrolyte disturbances involve abnormalities of sodium, potassium, and calcium (11). The prevalence of electrolyte imbalance in critically ill patients, including those with COVID-19, has been associated with increased morbidity and mortality (12).

Factors associated with electrolyte disturbances in ICU patients include severe burns, trauma, sepsis, brain damage, and heart failure, which lead to disturbances in fluid and electrolyte homeostasis. These disturbances can result from alterations in electrolyte absorption and distribution, changes in fluid status, hormonal alterations, and inadequate or excessive fluid administration (13).

It is important for healthcare providers in the ICU to be knowledgeable about fluid and electrolyte homeostasis and to pay attention to the administered fluid and medications to prevent and manage electrolyte disturbances (6).

1.2 Statement of the problem

The majority of patients in the intensive care unit (ICU) are susceptible to electrolyte abnormalities. Critically ill patients are susceptible to a number of clinical disorders and outcomes that can lead to either depletion or excess of essential electrolytes; this risk is frequently increased when several imbalances are present (14). Research has shown that critically ill patients who do not survive are more prone to having uncorrected electrolyte imbalances compared to those who do survive. Identifying these imbalances, even if they are asymptomatic or transient, is vital when delivering essential care to severely ill patients (15). For ICU patients, hypernatremia is a stand-alone risk factor for mortality (16, 17).

In the ICU setting, electrolyte disturbances are associated with increased morbidity, mortality, prolonged hospital stays, and higher healthcare costs. These imbalances can lead to disturbances in fluid and electrolyte homeostasis, affecting cellular processes and potentially causing serious complications such as coma, seizures, and cardiac arrest (18, 19). These imbalances can significantly impact patient outcomes and require careful monitoring and management to ensure safe patient care (20). The duration of patient management in the ICU is mainly dependent on the extent of electrolyte disturbances. The outcomes of critically ill patients are therefore important not only to the patients and their families but also to society. After ICU admission, the patient's outcome is completely based on the diagnosis and management of the primary illness and the level of electrolyte disturbance associated with multi-organ involvement (4, 5).

A high prevalence of electrolyte imbalances is common in critically ill patients; the most commonly reported ones are hypophosphatemia, hyponatremia, and hypomagnesemia (21).The global findings on

electrolyte abnormalities in ICU patients are getting worse (13). Ethiopian reports on the disturbance of electrolytes in patients indicate that the severity of the issue is worsening (8, 22).

Various factors contribute to electrolyte imbalances in the ICU, including socio-demographic factors (age, educational status, sex, and residency), inadequate or excessive fluid administration, underlying medical conditions such as heart failure, brain damage, sepsis, trauma, diabetes mellitus, acute renal failure, and severe burns, and the types of medication provided (13, 23, 24).

There are some studies on electrolyte imbalance done on specific cases like cardiac and metabolic patients at Gonder, Jimma, and Tikur Anbessa Specialized Hospital. As far as my search is concerned, there is no published research about electrolyte imbalance for all adult patients in an ICU setting. Moreover, there is no study done at Bahir Dar or in the Amhara region. Therefore, this study aims to assess the local prevalence and associated factors of common electrolyte imbalances in ICU patients.

1.3 Significance of the study

The result of this study will provide information for health care professionals in the ICU on how common electrolyte imbalances are and give insights into the possible contributing factors for electrolyte imbalance. The research has no direct benefit for those whose documents or records will be included in it. However, the indirect benefit of the research for the participant and other clients in the program is clear. This study will also be a paramount input for Federal Ministry of health and program planners working at various stages. Researchers will also benefit from the information for further investigations.

2. Literature review

2.1 Prevalence of common electrolyte imbalance

Several findings emerged from a review of the literature on the frequency of common electrolyte abnormalities in USA intensive care unit patients. According to one study, approximately 28% of critically ill individuals had hypophosphatemia (6). A different study that looked at the frequency of electrolyte abnormalities in 300 COVID-19 hospitalized patients discovered that hyponatremia was the most prevalent type of imbalance (25). Hyponatremia occurs in up to 30% of ICU patients and is associated with increased mortality and length of stay (16, 26-28). A study conducted at a large Brazilian center, hyponatremia was the most common electrolyte imbalance during this post-operative period (29). 11.1% of patients suffered mild hypernatremia, and 4.2% experienced moderate to severe hypernatremia; this amounts to an overall frequency of 15.3%, according to retrospective observational research conducted in France (30). In an emergency department in Norway, a retrospective cohort analysis revealed that the prevalence of hypernatremia was 1.1-4.4%, while the prevalence of hyponatremia was 2.3-44% (31). A study done in Zambia hypernatremia was 13% (32). In an international one-day point prevalence survey, hypophosphatemia, another electrolyte imbalance, was shown to be prevalent in at least 15% of critically ill patients (33).

Hypocalcemia is multifactorial, reported in up to 90% of inpatients, with hypocalcemia measured by ionized calcium reported in 20% of ICU patients (34). A retrospective cohort study carried out in the medical intensive care unit of South Korea discovered that 16.2% of critically ill patients had hyponatremia (35). 40% of patients in a two-year retrospective study from Turkey that examined the ICU records of 440 patients had hypokalemia (36).

An investigation conducted in Iraq revealed that 62% of intensive care unit patients had hypokalemia, 58% had hypochloremia, 58% had hypernatremia, 46% had hypocalcemia, 39% had both hyperchloremia and hyponatremia, 31% had hypercalcemia, and 6% had hypokalemia (13, 37). According to research, the frequency of hyponatremia in the general population is 7.7%, whereas in internal medicine, it is 3.37% in the Southeast (38). Electrolyte imbalance was found to be between 13% and 15% of the cases in a cross-sectional investigation of patients with repeated trauma in Hamedan, Iran (39).

The most prevalent electrolyte abnormalities among black Africans with HIV and diabetes mellitus, according to a South African study, were hypocalcaemia and hyponatremia (40). Hyperchloraemia occurred in 57.2% patients within 48 hours of ICU admission(41).According to a long-term study of the electrolyte profiles of COVID-19 patients receiving critical care in Egypt, patients with severe COVID-19 are more likely to experience electrolyte abnormalities such as hypokalemia, hyponatremia, and hypocalcemia (42).In Zambia hyperkalemia was 28 %(32).

A comparative cross-sectional study carried out at the University of Gondar Comprehensive Specialized Hospital revealed that 83.07% of diabetic patients had an overall electrolyte imbalance (22). 44.1% of patients admitted with metabolic syndrome had an overall frequency of electrolyte problems, according to another study done at Jimma Medical Center (8). In addition, hypokalemia, hypomagnesaemia, and hypocalcaemia were shown to be prevalent among patients who had undergone heart surgery in research done at Tikur Anbessa Specialized Hospital and Heart Center in Addis Ababa (43).

2.2 Factors associated with common electrolyte imbalances in the ICU

2.2.1 Socio-demographic characteristics Factors

Several factors have been identified by different studies as predictors of electrolyte imbalance in the ICU. A cross-sectional study conducted on patients admitted to the emergency department found that SARS-CoV-2 infection findings suggest that there are sex differences in electrolyte imbalances caused by SARS-CoV-2 infections. The results showed that hypokalemia was more frequent among women, while hypocalcaemia was more common among men (44).

Aging is associated with an increased risk of electrolyte imbalances, with hypernatremia and hyponatremia being the most common abnormalities found in the elderly. Normal physiological changes of aging, such as decreased urinary concentrating ability, can contribute to electrolyte disorders (45, 46).

A study conducted at the University of Gondar Comprehensive Specialized Hospital found that participants who lived in urban areas developed more electrolyte imbalances than those who lived in rural areas (22). Another study conducted at the Jimma Medical Center reported that the place of residence was not significantly associated with electrolyte disturbances among adults admitted with metabolic syndrome (8).

2.2.2 Clinical conditions

Several factors related to admission diagnosis can contribute to electrolyte imbalances. Medical conditions related to electrolyte imbalances include kidney disease, eating disorders such as anorexia and bulimia, congestive heart failure, alcohol use disorder, cirrhosis, thyroid disorders, adrenal gland disorders, and physical trauma such as severe burns or broken bones (31).

Serum sodium and potassium levels were significantly reduced in acute myocardial infarction cases when compared with normal healthy controls (47). 92 individuals with acute myocardial infarction were included in a case-control study. Patients with AMI showed significantly lower serum potassium concentrations than the control group. Twelve (27.3%) individuals with a simple AMI had low potassium levels, whereas 15 (31.25%) patients with AMI complicated by arrhythmia had hypokalemia (48). An observational study of postoperative patients revealed that 13% of patients who had normal sodium levels before they arrived in the ICU also developed dysnatremia while they were there. Additionally, all dysnatremic patient groups had significantly greater rates of congestive heart failure and liver failure; hyponatremia patients also had higher rates of diabetes and renal failure; and hypernatremia patients had higher rates of hypertension (49).

Hyponatremia is a common electrolyte imbalance observed in people who have experienced an acute stroke. Research indicated that within the first 24 hours after the start of the stroke, 15% of patients had hyponatremia (50). Hypokalemia is often present in patients who have had recent strokes. Retrospective study revealed that 18.7% of patients with acute ischemic stroke had hypokalemia (51). Hypokalemia was also associated with increased stroke severity, larger infarct sizes, and worse functional outcomes, according to the study. Their investigation yielded similar results, showing that three months after a stroke, hypokalemia was an isolated indication of poor functional outcomes (52)

At the Al-Sadr Teaching Hospital in Najaf, Iraq, a cross-sectional study was carried out. Based on these co-morbidities, it was shown that among the admitted patients, 44% had ischemic heart illnesses, 19% had digestive disorders, 10.5% had emergency orthopedic surgery, 7% had lung diseases and pneumonia, 6% had diabetes, 9% had sepsis, and 4.5% had seizures, all of which could have affected fluid balance (13). Patients with COPD are more likely to experience an imbalance in their calcium, potassium, and sodium levels, according to previous studies (53). Furthermore, hyponatremia was

shown to be the most prevalent electrolyte imbalance in a research conducted on hospitalized COVID-19 patients in Tehran, with hypomagnesemia coming in second (25).

2.2.3 Medications-related Factors

The administration of certain medications in the ICU can lead to drug-induced electrolyte disorders, affecting the balance of sodium, potassium, calcium, phosphate, and magnesium. Especially those in the ICU Diuretics can cause electrolyte imbalances, such as hypokalemia, while certain medications may affect renal function and electrolyte excretion (13, 54, 55). Antibiotics, chemotherapeutic agents, and corticosteroids also contribute to electrolyte imbalances, although the specific effects can vary (54).

Insulin therapy, especially in the treatment of diabetic ketoacidosis, potentially leading to hypokalemia. Drugs like dobutamine and other sympathomimetic agents are associated with hypokalemia, particularly in the setting of critical illness. Methylxanthine derivatives, such as theophylline, can impact calcium and potassium levels, potentially leading to disturbances in these electrolytes. The predominating factors are: using sodium bicarbonate solutions to correct metabolic acidosis and urinary tract disorders; using diuretics, urea, or glucose solutions (6). A two-year retrospective study from Turkey analyzing the ICU records found that administration of insulin, diuretics, and beta-adrenergic agents was significantly correlated with a higher incidence of hypokalemia (36). A facility-based cross-sectional study of serum electrolyte disorder and its associated factors among adults admitted with metabolic syndrome in Jimma Medical Center, South West Ethiopia, shows that diuretics, anti-diabetics, and other medications can affect electrolyte levels (8).

2.2.4 IV fluid-related factors

In the intensive care unit (ICU), the administration of intravenous (IV) fluids can significantly impact electrolyte balance. Crystalloid solutions, such as 0.9% saline and lactated Ringer's solution, are commonly used for fluid resuscitation, replacement, and maintenance in critically ill patients. These solutions contain varying concentrations of electrolytes, and their use should be carefully considered to avoid electrolyte disturbances (56). The prospective interventional study conducted at the general surgery ward of AL-Hilla Teaching Hospital, Babel Governorate, Iraq, showed that inadequate or excessive fluid administration: improper prescription of IV fluids can lead to electrolyte imbalances, such as hyponatremia or hypernatremia (57). A two-year retrospective study from Turkey analyzing the ICU records found that blood transfusion was also found to be highly correlated with hypokalemia (36).

2.3 Conceptual framework

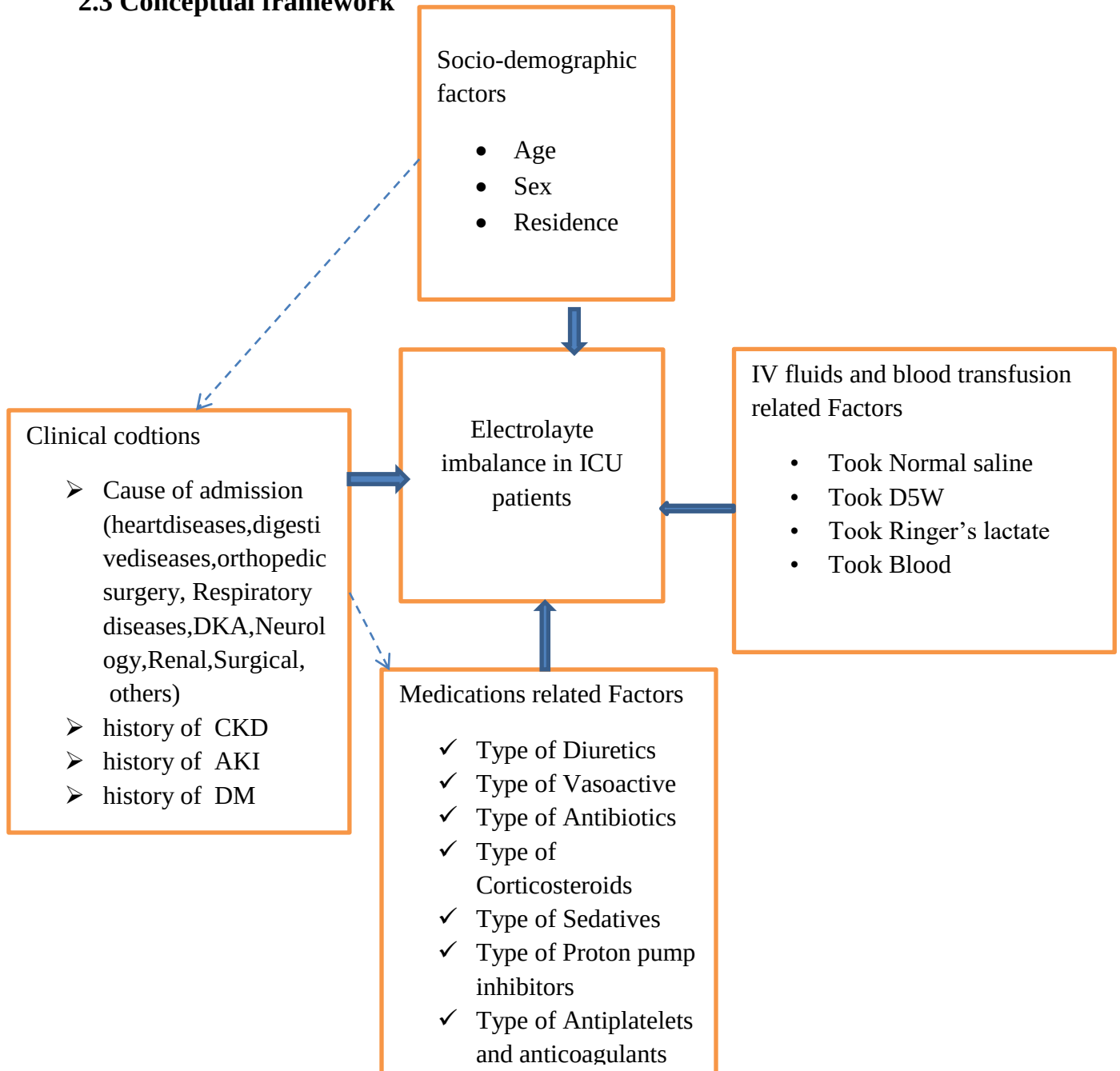


Figure 1: Conceptual framework to show factors associated with common electrolyte imbalance in ICU adapted from reviewing different studies (6, 13, 21, 43, 58-60).

3. Objectives

3.1 General objective

- To assess the electrolyte imbalance and associated factors among patients in intensive care units of public hospitals in Bahir Dar, Ethiopia, 2024.

3.2 Specific Objectives

- To determine the prevalence of electrolyte imbalance among patients in intensive care units of public hospitals in Bahir Dar, Ethiopia, 2024.
- To identify the factors associated with electrolyte imbalance among patients in intensive care units of public hospitals in Bahir Dar, Ethiopia, 2024.

4. Methods and Materials

4.1 Study design and period

An institution-based cross-sectional study was conducted in Bahir Dar public hospitals from May 1 to May 30, 2024.

4.2 Study area

The study was conducted at two intensive care units (ICUs) within comprehensive specialized hospitals in Bahir Dar, Ethiopia. These hospitals are Tibebe Ghion Comprehensive Specialized Hospital and Felege Hiwot Comprehensive Specialized Hospital. Tibebe Ghion Comprehensive Specialized Hospital, established in 2018, is located 565 kilometers from Addis Ababa and serves more than 5 million people with 9 adult ICU beds. Felege Hiwot Comprehensive Specialized Hospital, which started serving patients in 1963, is also situated in Bahir Dar and provides care to over 5 million people with 12 adult ICU beds (61, 62).

4.3 Population

4.3.1 Sources population

The source population were all adult patients who were admitted to the ICU of public hospitals in Bahir Dar, Ethiopia.

4.3.2. Study population

All adult patients who were admitted to the ICU of public hospitals in Bahir Dar, Ethiopia, from January 1, 2021, to December 30, 2023.

4.3.3. Sampling unit

Those randomly selected patient charts from January 1, 2021, to December 30, 2023.

4.4 Eligibility criteria

4.4.1 Inclusion criteria

- Age: ≥ 18 years..
- Patient who had at least one lab result after admission
- Patient who had normal electrolyte before admission .

4.4.2 Exclusion criteria

Patients with renal replacement therapy

4.5 Sample size and Sampling procedure

The sample size for the current study was determined based on a single population proportion formula. Since there was no similar national study found during the literature search, a proportion of 0.5 was considered to yield the maximum sample size.

$$n = \frac{(Z_{\alpha/2})^2 * P(1-P)}{(d)^2}$$

Where: n= minimum sample size required

$Z_{\alpha/2}$ = standard normal variable with 95% CI (1.96)

d= margin of error =0.05, p= 50% = 0.5

$$n = \frac{(1.96)^2 * 0.5(1-0.5)}{0.05 * 0.05} = \frac{1.96 * 1.96(0.5 * 0.5)}{0.0025} = 384$$

Then, after adding 5% for incomplete and absent cards, the sample size was 404.

To determine the required sample size for the specific objectives by calculated on open Epi info version 7.2 software using factors associated with electrolyte imbalance among patients in intensive care units adult patients admitted with the following assumptions: 95% confidence interval, 5% margin of error, and a power of 80% and ratio of exposed to unexposed of 1:1 by taking study findings from **(Table 1)**.

Table 1:sample size calculation with different variable factors that are associated with electrolyte imbalance among patients in intensive care units of public hospitals in Bahir Dar ,Ethiopia,2024.

Variab les	Confidenc e interval	Power by %	OR/RR	Ratio of exp to unexpe ct	% of outcomes inunexpose d	Sample size	Final Sample size with 5% non respose rate	p- value	Feferen ce
Residenc e	95%	80	OR2.58 RR1.69	1:1	56	162	170	0.00	(8)
Diuretics	95%	80	OR4.34 RR2.19	1:1	64.2	74	77.7	0.00	(8)
digestive	95%	80	OR 2.5	1:1	13.7	266	279.3	<0.05	(63)

disease			RR2.07						
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Finally, the required sample size for this particular study is decided by taking the largest sample size, which is 404.

4.5.1 Sampling procedure and sampling technique

There are two comprehensively specialized hospitals in Bahir Dar. From January 1, 2021, to December 30, 2023, over a three-year period, 2790 patients visited the ICUs of in the 2 hospitals. From those 1865 cards were meet Inclusion criteria were selected from HMIS register. The sample size was proportionally allocated to each respective hospital based on their population size. Finally, simple random sampling technique was used to select a sample of 404 participants from each hospital by the data collectors.

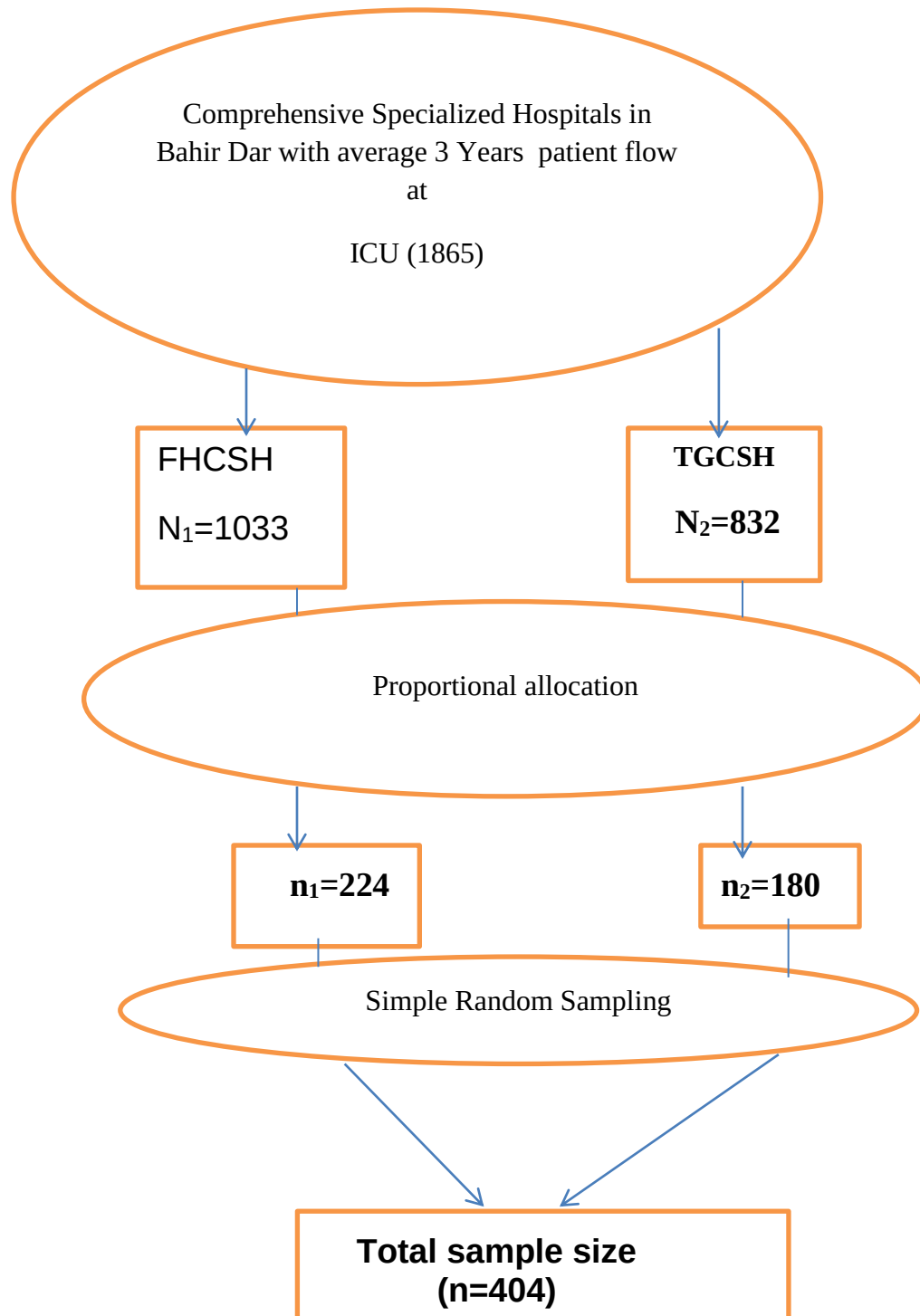


Figure 2:schematic presentation of sampling procedure to select study participants among adult patients attending ICU of Bahirdar pulic hospitals ,Bahir DAR Ethiopia 2024.

4.6 Variables of the Study

4.6.1 Dependent Variable

Electrolyte imbalance in ICU patients

4.6.2 Independent Variables

Socio-demographic factors: age, sex, residence

Clinical conditions : cause of admission, Comorbidity condition (CKD, AKI, and DM)

Medication-related Factors: Types of (Diuretics, Vasoactives, Antibiotics, Corticosteroids, Sedatives, Proton Pump Inhibitors, Antiplatelets, and Anticoagulants)

IV fluids and blood transfusion-related factors: normal saline, D5W, Ringer's lactate, blood

4.7 .Operational Definition

Electrolyte imbalance; test results showing a changed level from the normal ranges of at least one of the electrolytes in ICU stay (K^+ , Cl^- or Na^+).

The following ranges were used to determine the imbalance for each electrolyte based on the reference range: below the reference range is hypo, and above the reference range is hyper.

Normal range: Na^+ = 135–145 mmol/L

Hyponatremia: a sodium level of less than 135 mEq/L

Hypernatremia: a sodium level greater than 145 mEq/L

Normal range: k^+ = 3.5–5.5 mEq/L

Hypokalemia-potassium level of less than 3.5 mEq/L

Hyperkalemia - potassium level of greater than 5.5 mEq/L

Normal range: Cl^- = 98–107 mmol/L

Hypochloremia: a chloride level of less than 98 mEq/L

Hyperchloremia: a chloride level greater than 107 mEq/L

4.8. Data Collection Tool and Procedure

The data were collected from the patients attending Bahir Dar Comprehensive Specialized Hospitals ICU using a structured questionnaire. The patient chart review laboratory parameters were the first results after admission to the ICU. The questionnaire is adapted from different literatures (6, 13, 21, 43, 58-60). The questionnaire has five parts with a total of 31 questions. The first part contains three sociodemographic questions; section two contains four clinical questions; section three contains 10 medication-related questions; section four contains four IV fluids and blood transfusion-related questions; and section five contains 10 lab parameters-related questions. The data were collected by 2 trained BSc nurses and 1 MSc nurse supervisor using the Kobo Toolbox software to collect from chart reviews. Eligible patients were identified by data collectors.

4.9 Data Quality Control

Data collectors and supervisors were trained for one day before data collection about the objective of the questionnaires, the required ethical conduct, the confidentiality of the information, and the questionnaire to ensure consistency and reduce variations between data collectors. Daily communication was made between the principal investigator and the supervisor and the data collectors throughout the data collection process. A pre-test was conducted on 5%(20) of the participants in Tibebe Ghion Comprehensive Specialized Hospital on April 15 2024 cronbach`s Alpha was 0.715 and the obtained data was reviewed for accuracy, completeness, clarity, and consistency before the actual data collection.

4.10 Data Processing and Analysis Plan

The data collected by the data collectors using Kobo Toolbox Collect software was exported to SPSS version 26 for data processing and analysis. Descriptive statistics, including frequencies, median with interquartile range, were computed and presented in texts, tables, and graphs. Multicollinearity was checked no multicollinearity, and the model's fitness was tested by using the Hosmer-Lemeshow goodness of fit test and it was fit. Both bivariable and multivariable logistic regression analyses were used to identify associated factors. Variables significant at p-value <0.25 in the bivariable analysis were candidates and entered into the multivariable logistic regression analysis model to control the effect of different confounding factors while assessing the effect of each independent variable with the outcome variable for multivariable analysis. Odds ratios (OR) with 95% confidence intervals (CI) were computed

to evaluate the strength of the association, and variables with a p-value less than 0.05 were considered statistically significant with the outcome variable.

4.11 Ethical consideration

This study was approved by the Institutional Review Board of SPHMMC, and ethical clearance was obtained from the board. A formal supportive letter was written to Bahir Dar Comprehensive Specialized Hospitals. After getting permission from the hospital administration, the request letter was written for the concerned bodies of the respective departments. Following this, searching and obtaining the selected samples' medical records were processed with the assigned person.. Data was kept anonymously by coding; information will not be shared with others, and the collected data will be password-protected in order to maintain confidentiality.

4.12 Dissemination Plan

The result of this study will be submitted and presented to the Department of Emergency and Critical Care Nursing, School of Nursing, SPHMMC. Then, the document will be disseminated to Bahir Dar Comprehensive Specialized Hospitals, Amhara Public Health Institute, Amhara Health Bureau, and the Federal Ministry of Health. Furthermore, an attempt will be made to publish it in a reputable journal.

5.Results

5.1 Socio-demographic characteristics of study participants

Out of the total 404 recruited study participants, 401 participated in the study, yielding a response rate of 99.3%. The median age of the participants was 41 (IQR: 30-55) years. More than half (54.6%, 56.4%) of the study participants were males and from rural areas, respectively (**Table 2**).

Table 2:socio-demographic characteristics of adult patients attendind the ICU of Bahir Dar public hospitals ,Bahir Dar ,Ethiopia 2024(n=401)

Variables	Category	Frequency	Percent
Sex	Male	219	54.6
	Female	182	45.4
Place of residence	Urban	175	43.6
	Rural	226	56.4
Age in years	<64	346	86.3
	>=64	55	13.7

5.2 Clinical conditions

The study participants were admitted by different diagnosis. About 35.9% and 28.9% of participants were admitted for respiratory and CVS problems respectively. About 12.5% of participants were admitted in neurology and 16.7% were admitted in surgical diagnosis. Only 3% and 1% were admitted for orthopedic and renal disease respectively. The overall death from 401 was 107 (26.7%). From those died 92 (86%) has electrolyte imbalance (**Table 3**).

Table 3:clinical conditions characteristics of adult patients attending ICU of Bahir Dar public hospitals Bahir Dar ,Ethiopia 2024(n=401)

	Category	Frequency	Percent
Respiratory	No	257	64.1
	YES	144	35.9
CVS	No	285	71.1
	YES	116	28.9
GIT	No	377	94.0
	YES	24	6.0
orthopedic disease	No	389	97.0
	YES	12	3.0
DKA	No	389	97.0
	YES	12	3.0
Neurology	No	351	87.5

	YES	50	12.5
Renal	No	397	99.0
	YES	4	1.0
Surgical	No	334	83.3
	YES	67	16.7
Others	No	372	92.8
	YES	29	7.2
Is the patient known AKI	No	397	99
	YES	4	1
Is the patient known diabetic	No	377	94
	YES	24	6
Is the patient known CKD	No	392	97.8
	YES	9	2.2
Outcome	Discharged/Imp roved	294	77.3
	Died	107	26.7

Others*: Tetanus, GBS, Poisoning, etc.

5.3Medications

Diuretics were administered to 25.9% of the study participants. High percentage (95.2%) of diuretics were accounted for furosemide. Vasoactive medications were administered for 20.9% of participants. Antibiotics and corticosteroids were administered for 82.5% and 17% of the study Participants respectively. Regarding antiplatelets and anticoagulants, heparin was administered for 93.9% of the study participants. 70.6% of patients were given normal saline while 31.2 and 27.7% of patients took Ringer's lactate and D5W, respectively. 11.7% of patients received blood product transfusions (**Table 4**).

Table 4: medications ,IV fluids and blood transfusion -releted factors of adult patients attending the ICU of Bahir Dar public hospitals ,Bahir Dar,Ethiopia 2024(n=401)

Variables	Category	Frequency	Percent
Diuretics	Yes	104	25.9
	No	297	74.1
Furosemide	Yes	99	95.2
	No	5	4.8

Thiazide	Yes	10	9.6
	No	94	90.4
Spironolactone	Yes	8	7.7
	No	96	92.3
Vasoactive	Yes	84	20.9
	No	317	79.1
Epinephrine	Yes	63	75
	No	21	25
Dopamine	Yes	32	38.1
	No	52	61.9
Antibiotics	Yes	331	82.5
	No	70	17.5
Corticosteroids	Yes	68	17.0
	No	333	83.0
Sedatives	Yes	177	44.1
	No	224	55.9
Proton pump inhibitors	Yes	314	78.3
	No	87	21.7
Antiplatelet and anticoagulants	Yes	296	73.8
	No	105	26.2
Aspirin	Yes	50	16.9
	No	246	83.1
Warfarin	Yes	7	2.4
	No	289	97.6
Heparin	Yes	278	93.9
	No	18	6.1
Ringer's lactate	Yes	125	31.2
	No	262	65.3
D5W	Yes	139	34.7
	No	290	72.3
Blood product Transfusion	Yes	47	11.7
	No	354	88.3
Normal saline	Yes	283	70.6
	No	118	29.4

5.4 Prevalence of electrolyte imbalance

A total of 336 (83.8%) electrolyte imbalances were detected in adult ICU patients (**Figure 3**). Hyponatremia (33.4%), hypokalemia (31.9%), and hyperchloremia (31.4%) were the most common electrolyte imbalances in patients (**Figure 4**).

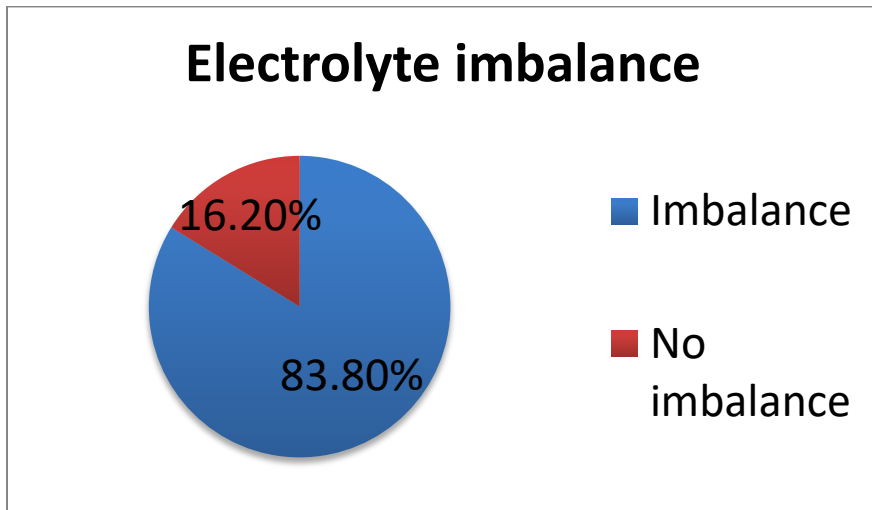


Figure 3:prevalence of electrolyte imbalance in adult patients attending the ICU of Bahir Dar public hospitals ,Bahir Dar Ethiopia 2024(n=401)AR Ethiopia 2024 (n = 401).

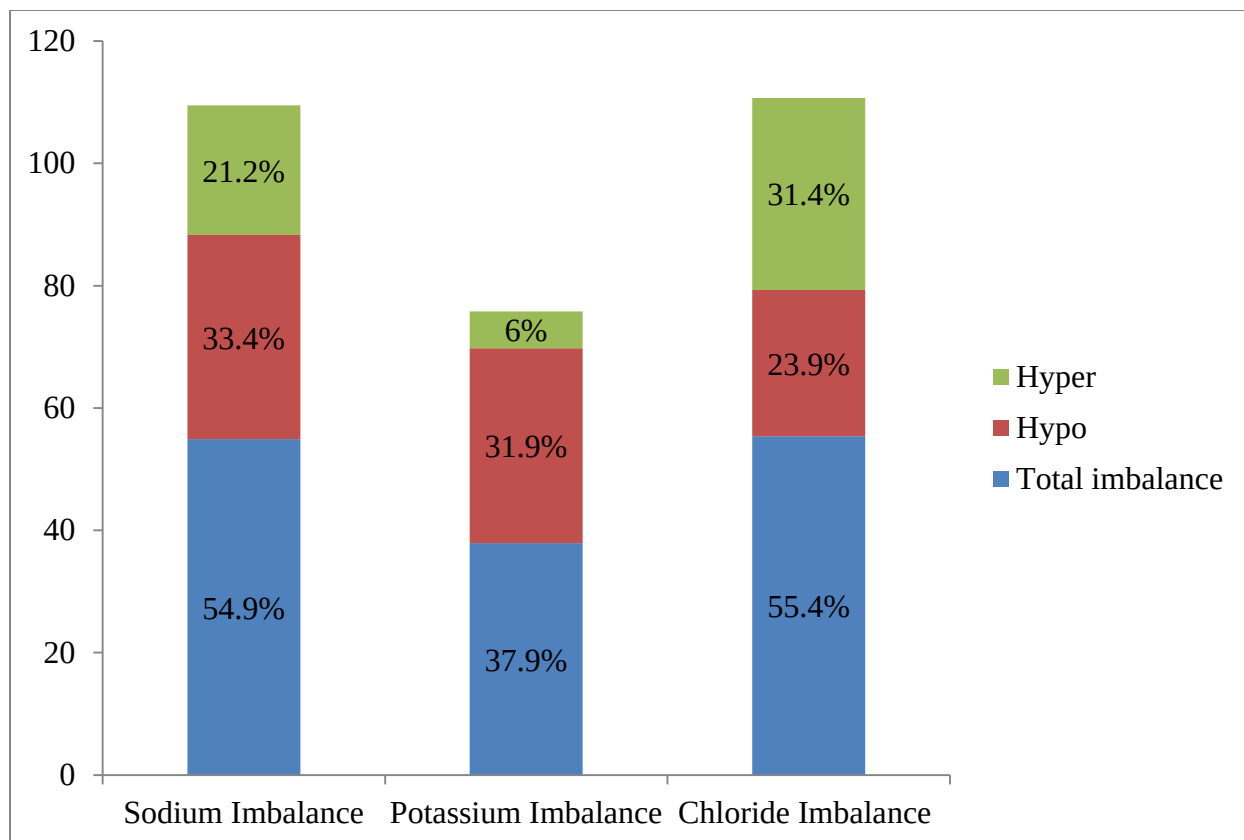


Figure 4:prevalence of sodium,potassium and chloride imbalance during hospitalization in ICUs adult patients attending the ICU of Bahir Dar ,Ethiopia 2024(n=401)

5.5 Factors associated with common electrolyte imbalances in the ICU

In bi-variable binary logistic regression analysis, twelve independent variables such as place of residence, cause of admission for (heart disease, digestive disease, neurology, and surgical), CKD status, type of medications (diuretics, vasoactives, and antibiotics), and types of fluids (normal saline, Ringer's lactate, and dextrose 5% in water) were candidate variables for multivariable binary logistic regression analysis.

In multivariable binary logistic regression analysis, use of diuretics, use of vasoactive, use of normal saline, and use of Ringer's lactate showed statistically significant associations with electrolyte imbalances in the ICU. Patients who took diuretics in the ICU were 4.5 times more likely to have electrolyte imbalances as compared to patients who didn't (AOR: 4.532; 95 CI: 1.971, 10.42). Patients who took Vasoactive in the ICU were six times more likely to have electrolyte imbalances as compared to patients who didn't (AOR: 5.989; 95 CI: 1.253, 28.61). Patients who took normal saline in the ICU

were three times more likely to have electrolyte imbalances as compared to patients who didn't (AOR: 2.956; 95% CI: 1.424, 6.137). Patients who took Ringer's lactate in the ICU were 4.2 times more likely to have electrolyte imbalances as compared to patients who didn't (AOR: 4.192; 95% CI: 1.452, 12.109%). (**Table 5**).

Table 5:Bi-variable and multivariable logistic regression analysis of factors associated with electrolyte imbalance adult patients attending the ICU of Bahir Dar public hospitals ,Bahir Dar ,Ethiopia 2024(n=401)

Variables		Electrolyte Imbalance		OR at 95% CI	
		Yes	No	COR (95% CI)	AOR (95%CI)
Place of residence(1)	Urban	140	35	1.633(.958,2.785)	1.012(0.545,1.880)
	Rural	196	30	1	1
cause of admission /Heart disease	Yes	93	23	0.699(0.398,1.226)	0.925(0.405,2.115)
	No	243	42	1	1
Cause of admission /digestive disease	Yes	23	1	4.703(0.624,35.45)	1.020(0.120, 8.635)
	No	313	64	1	1
Cause of admission /neurology	Yes	35	15	0.388(0.197,0.761)	0.654(0.272,1.568)
	No	301	50		1
cause of admission /surgical	Yes	63	4	3.519(1.234,10.07)	1.759(0.440,7.034)
	No	273	61		1
Is the patient known CKD	Ye	6	3	0.376(0.092,1.542)	0.175(0.026,1.196)
	No	330	62		1

Diuretics	Yes	99	9	2.599(1.238,5.458)	4.532(1.971,10.42*
	No	237	56	1	1
Vasoactive	Yes	81	3	6.565(2.007,21.478)	5.989(1.253,28.61*
	No	255	62		1
Antibiotics	Yes	284	47	2.092(1.127,3.882)	0.712(0.317,1.601)
	No	52	18		1
Normal saline	Yes	246	27	3.847(2.221,6.663)	2.956(1.424,6.137*
	No	90	38		1
Ringer's lactate	Yes	120	5	6.667(2.606,17.053)	4.192(1.452,12.109)*
	No	216	60		1
dextrose 5% in water	Yes	99	14	1.522(0.805,2.875)	0.849(0.399,1.807)
	No	237	51		1

NB* indicates P-value<0.05, and 1-reference.

6. Discussion

Among 401 enrolled adult ICU patients, this study aimed to assess electrolyte imbalance and associated factors among patients in intensive care units. Accordingly, the prevalence of electrolyte imbalance among patients in intensive care units in this study was found to be 83.8% (95% CI: 80, 87.5). Since the three electrolytes were considered together and an imbalance among any of them was noted, this might be the reason for the high incidence. This finding is higher than the study done in Turkey (75.2%) and India (32%) (64, 65). This may be due to the advanced availability of ICU care and the difference in the study population.

Hyponatremia was the most frequent abnormality noted in 33.4% of cases. This finding is consistent with the previous studies conducted in India(30%)(28). The similarity in study as they focused since ICU patients took excess fluid for different reason leading to a dilution of sodium in the blood, may

have contributed to the findings. Additionally, the small sample size, with only 100 participants included in the study, could have influenced the results.

This finding is higher than the study conducted in South Korea (16.2%) and Turkey (13.8%) (35, 64). This discrepancy might be due to the difference in the study population and better ICU care. However, this finding is lower than the study conducted in Iraq (39%)(13). This discrepancy might be due to the difference in the study population and the small sample size, in which they used only 52 study participants.

This study found that hypernatremia was 21.2%; this finding is higher than the study conducted in France (15.3%), Norway (4.4%), Turkey (16.8%), and Zambia(13%)(30-32, 64). This discrepancy might be due to the difference in the study population and the variation in the level of the ICU health care system.

Hypokalemia was observed in 31.9% of the study participants. This finding is higher than the study conducted in Zambia (24%)(32). This discrepancy might be due to the difference in the study population and sample size. It may be due to the small sample size, such that 100 participants were included. However, this finding is lower than the study conducted in Turkey (40%), Iraq (62%), and India (48%) (13, 36, 65, 66). This discrepancy might be due to the variation in the level of ICU health care and the and the number of laboratory results included since this study is taking one result.

Hyperkalemia was observed in 6% of However, this finding is lower than the study conducted in Turkey (19.8%), India (52%), and Zambia (28%) (32, 64, 65). This discrepancy might be due to the small sample size Turkey and zambia , such that 64 and 100 participants were included, respectively. India study also takes those who have imbalanced during admission.

This study found that hypochloremia was 23.9%. This finding is higher than the study conducted in Japan 8.8%(37). This discrepancy might be due to the difference in the study population and the variation in the level of the ICU health care system..

Hyperchloremia 31.4% However, this finding is lower than the study conducted in Mexico (47.71%) and South Africa (57.2%)(41, 67). This discrepancy might be due to the variation in the level of ICU health care,frequency of determination and the number of laboratory results included since this study is taking one result.

Patients who took diuretics in the ICU were more likely to have electrolyte imbalances as compared to patients who didn't. This finding is supported by the studies conducted in Brazil(68) and South Korea(6) . The reasons for these diuretics are that they inhibit sodium and chloride reabsorption in the nephron, leading to increased excretion of these ions(69). This can disrupt the normal balance of other electrolytes, like potassium and calcium. Additionally, diuretics may impair the kidney's ability to concentrate urine, leading to excessive water loss and hyponatremia.

Patients who took Vasoactive in the ICU were more likely to have electrolyte imbalances as compared to patients who didn't. This finding is supported by the studies conducted in South Korea(6) and India(55). The possible reason may be that reduced perfusion to the kidneys due to hypotension can impair the kidney's ability to regulate fluid and electrolyte balance. Activation of hormonal systems like the renin-angiotensin-aldosterone system and vasopressin can disrupt normal electrolyte regulation. Tubular damage from ischemia or nephrotoxicity can further impair renal electrolyte handling.

Patients who took normal saline in the ICU were more likely to have electrolyte imbalances as compared to patients who didn't. This finding is supported by the studies conducted in Brazil(68), South Korea(6) and India(55) . The possible reason may be that normal saline contains high levels of chloride, which can cause renal vasoconstriction and worsen acidemia. Excessive sodium and chloride loads from normal saline can also impair the kidneys' ability to excrete the excess, leading to hypernatremia(70).

Patients who took Ringer's lactate in the ICU were more likely to have electrolyte imbalances as compared to patients who didn't. This finding is supported by the studies conducted in Brazil(68)and India(55) . The possible reason may be that excessive administration of Ringer's lactate, like any intravenous fluid, can lead to fluid overload and dilutional hyponatremia. In patients with liver dysfunction, the lactate component of Ringer's lactate may not be properly metabolized, leading to metabolic acidosis and hyperkalemia(71).

7. Limitations and strengths of the study

In this study, only the first laboratory results after ICU admission were considered. This may underreport the magnitude of the electrolyte imbalance. Also, the secondary data collection method is a

limitation in that some records having incomplete data like body mass index , Calcium and magnesium test.

Despite these limitations, the strength of the study is in contrast to most of the previous studies, this study incorporated many electrolyte imbalances and the study tried to compare the prevalence of electrolyte imbalance for all medical conditions than any other previous study conducted.

8. Conclusions and Recommendation

8.1 Conclusions

Based on the results of this study, the combined electrolyte imbalance in ICU patients was found that 83.7% patients in intensive care unit has electrolyte imbalance. Taking different medications and fluids like diuretics, Vasoactive, normal saline, and Ringer's lactate showed a statistically significant association with electrolyte imbalances in the ICU patients. Hypokalemia was evident in many ICU patients. It can lead to ventricular arrhythmias and increased mortality. Hypochloremia and hyponatremia were fairly common findings among hospitalized ICU patients.

8.2 Recommendation

To Policy makers

The Policy makers better to develop an electrolyte management policy in the intensive care unit that will lead to the timely diagnosis and treatment of the identified electrolyte abnormalities.

To health care providers

For logical decisions to be made about ICU care, routing monitoring and serum electrolyte profile evaluation are crucial. Tight monitoring of patients taking diuretics, vasoactive, normal saline, and Ringer's lactate helps prevent electrolyte imbalance and related complications.

To hospitals

It's essential to keep enough supplies of laboratory reagents and other associated consumables on hand so that electrolyte abnormalities can be promptly treated by performing electrolyte analysis on time.

To future researchers

To evaluate other electrolyte abnormalities, such as those involving calcium and magnesium. A prospective flow-up study that looks at the amount of medication and fluids from the time of admission to the end of care in the ICU.

9 .References

1. Ficalora RD, Mueller PS. Mayo Clinic internal medicine board review: Oxford University Press, USA; 2013.
2. Nowrouzi B, Gohar B, Smith C, Nowrouzi-Kia B, Khan R, McDougall A, et al. An examination of health, medical and nutritional information on the Internet: a comparative study of Wikipedia, WebMD and the Mayo Clinic Websites. *The International Journal of Communication and Health*,(6). 2015.
3. Bera DK, Majumder S, Majumder A. Electrolyte Imbalance. *The Protocol Book for Intensive Care*. 2018:388.
4. Marshall JC, Bosco L, Adhikari NK, Connolly B, Diaz JV, Dorman T, et al. What is an intensive care unit? A report of the task force of the World Federation of Societies of Intensive and Critical Care Medicine. *Journal of critical care*. 2017;37:270-6.
5. Christensen M, Liang M. Critical care: A concept analysis. *International Journal of Nursing Sciences*. 2023.
6. Lee JW. Fluid and electrolyte disturbances in critically ill patients. *Electrolytes & Blood Pressure: E & BP*. 2010;8(2):72.
7. Melia D, Saha S. 34th International Symposium on Intensive Care and Emergency Medicine. *Critical Care*. 2014;18(1):P1.
8. Timerga A, Kelta E, Kenenisa C, Zawdie B, Habte A, Haile K. Serum electrolytes disorder and its associated factors among adults admitted with metabolic syndrome in Jimma Medical Center, South West Ethiopia: Facility based crosssectional study. *PloS one*. 2020;15(11):e0241486.
9. Ishaque S, Hassan R. 1443: ELECTROLYTE ABNORMALITIES IN CRITICALLY ILL CHILDREN: REVIEW FROM A LOW-MIDDLE-INCOME COUNTRY. *Critical Care Medicine*. 2020;48(1):698.
10. Bulloch MN, Cardinale-King M, Cogle S, Radparvar S, Effendi M, Jagpal S, et al. Correction of Electrolyte Abnormalities in Critically Ill Patients. *Intensive Care Research*. 2024:1-19.
11. Kandasamy M, Perry V. Common electrolyte disturbances in primary care. *InnovAiT*. 2013;6(6):334-43.
12. Molina P, Canto A, Said MZ-M, Villalobos A, Terrazas A, Figueroa R, et al. 542: ELECTROLYTE IMBALANCE AND CLINICAL OUTCOMES IN HOSPITALIZED COVID-19 PATIENTS. *Critical Care Medicine*. 2024;52(1):S244.
13. Ibrahim SL, Alzubaidi ZF, Al-Maamory FAD. Electrolyte disturbances in a sample of hospitalized patients from Iraq. *Journal of Medicine and Life*. 2022;15(9):1129.
14. Mousavi S-AJ, Shahabi S, Mostafapour E, Purfakharan M, Fereshtehnejad S-M, Amini J, et al. Comparison of the serum electrolyte levels among patients died and survived in the intensive care unit. *Tanaffos*. 2012;11(4):36.
15. Hu J, Wang Y, Chen R, Zhang X, Lin J, Teng J, et al. Electrolyte and acid-base disturbances in critically ill patients: A retrospective and propensity-matched study. *Int J Clin Exp Med*. 2017;10(1):992-1003.
16. Funk G-C, Lindner G, Druml W, Metnitz B, Schwarz C, Bauer P, et al. Incidence and prognosis of dysnatremias present on ICU admission. *Intensive care medicine*. 2010;36:304-11.
17. Lindner G, Funk G-C. Hyponatremia in critically ill patients. *Journal of critical care*. 2013;28(2):216. e11-. e20.
18. Nadeem MF, Butt AM, Ashraf W, Matti N, Farooq MA, Nasim Mb, et al. The Impact of Fluid and Electrolyte Imbalance on the Severities of Diseases and Their Management in Developing Countries. *Handbook of Medical and Health Sciences in Developing Countries: Education, Practice, and Research: Springer*; 2024. p. 1-20.
19. Naseem F, Saleem A, Mahar IA, Arif F. Electrolyte imbalance in critically ill paediatric patients. *Pakistan journal of medical sciences*. 2019;35(4):1093.
20. Barron R, Freebairn R. Electrolyte disorders in the critically ill. *Anaesthesia & Intensive Care Medicine*. 2010;11(12):523-8.

21. Moutushi SS, Akter T, Haq MA, Ahmad R, Sinha S, Adnan N, et al. Electrolyte Imbalance Among Bangladeshi Patients With COVID-19. *Cureus*. 2023;15(2).
22. Eshetu B, Worede A, Fentie A, Chane E, Fetene G, Wondifraw H, et al. Assessment of Electrolyte Imbalance and Associated Factors Among Adult Diabetic Patients Attending the University of Gondar Comprehensive Specialized Hospital, Ethiopia: A Comparative Cross-Sectional Study. *Diabetes, Metabolic Syndrome and Obesity*. 2023;1207-20.
23. Tongyoo S, Viarasilpa T, Permpikul C. Serum potassium levels and outcomes in critically ill patients in the medical intensive care unit. *Journal of International Medical Research*. 2018;46(3):1254-62.
24. Reintam Blaser A, van Zanten A, de Man A. Electrolytes in the ICU. *Annual Update in Intensive Care and Emergency Medicine 2022*: Springer; 2022. p. 183-200.
25. Rostami Z, Shafei S, Nemati E, Einollahi B, Rostami A. POS-109 COMMON ELECTROLYTE ABNORMALITIES IN HOSPITALIZED COVID-19 PATIENTS. *Kidney International Reports*. 2021;6(4):S45.
26. Braun MM, Barstow CH, Pyzocha NJ. Diagnosis and management of sodium disorders: hyponatremia and hypernatremia. *American family physician*. 2015;91(5):299-307.
27. Spasovski G, Vanholder R, Allolio B, Annane D, Ball S, Bichet D, et al. Clinical practice guideline on diagnosis and treatment of hyponatraemia. *Nephrology Dialysis Transplantation*. 2014;29(suppl_2):i1-i39.
28. Upadhyay S, Bhalerao N, Pratinidhi SA. Study of level of consciousness and electrolyte abnormalities in patients admitted to intensive care unit (ICU). *Int J Contemp Med Res*. 2017;4(8):1739-42.
29. Tolesani Junior O, Pelli Seabra M, Berenger T, Knibel M. Prevalence of Electrolyte Disorders during the Immediate Postoperative Intensive Care-The Experience of a Large Brazilian Center.
30. Darmon M, Timsit J-F, Francais A, Nguile-Makao M, Adrie C, Cohen Y, et al. Association between hypernatraemia acquired in the ICU and mortality: a cohort study. *Nephrology Dialysis Transplantation*. 2010;25(8):2510-5.
31. Tazmini K, Nymo SH, Louch WE, Ranhoff AH, Øie E. Electrolyte imbalances in an unselected population in an emergency department: A retrospective cohort study. *PloS one*. 2019;14(4):e0215673.
32. Sheyo N. Changes in selected electrolytes in adult intensive care patients at the University Teaching Hospital, Lusaka, Zambia: University of Zambia; 2019.
33. Berger M, Appelberg O, Reintam-Blaser A, Ichai C, Joannes-Boyau O, Casaer M, et al. Prevalence of Hypophosphatemia in the ICU—results of an international one-day point prevalence survey. *Clinical Nutrition*. 2021;40(5):3615-21.
34. Cooper MS, Gittoes NJ. Diagnosis and management of hypocalcaemia. *BMJ (Clinical research ed)*. 2008;336(7656):1298-302.
35. Sim JK, Ko R-E, Na SJ, Suh GY, Jeon K. Intensive care unit-acquired hyponatremia in critically ill medical patients. *Journal of Translational Medicine*. 2020;18:1-9.
36. Gerçek A, Umuroğlu T, Feyza İ, GÖĞÜS Y. The etiology and incidence of hypokalemia in intensive care unit. *Marmara Medical Journal*. 2003;16(1):32-5.
37. Tani M, Morimatsu H, Takatsu F, Morita K. The incidence and prognostic value of hypochloremia in critically ill patients. *The Scientific World Journal*. 2012;2012(1):474185.
38. Xiao M, Wang X, Wang H, Du F, Yao Y, Wang X, et al. Risk factors for hyponatremia in acute exacerbation chronic obstructive pulmonary disease (AECOPD): a multicenter cross-sectional study. *BMC Pulmonary Medicine*. 2023;23(1):1-11.
39. Rezaei B, Ramazani E, Amiri R, Sanaei Z. A cross-sectional study on the prevalence of electrolyte abnormalities in multiple trauma patients in Hamedan, Iran. *Health Science Reports*. 2021;4(2):e239.
40. Pillay P, Pillay S, Mchunu N. The spectrum of electrolyte abnormalities in black African people living with human immunodeficiency virus and diabetes mellitus at Edendale Hospital, Pietermaritzburg, South Africa. *Southern African journal of HIV medicine*. 2020;21(1):1-8.

41. de Vasconcellos K, Skinner DL. Hyperchloraemia is associated with acute kidney injury and mortality in the critically ill: A retrospective observational study in a multidisciplinary intensive care unit. *Journal of Critical Care*. 2018;45:45-51.
42. Abosamak MF, Szergyuk I, de Oliveira MHS, Almutairi SM, Alharbi JS, Benoit SW, et al. Longitudinal analysis of electrolyte profile in intensive care COVID-19 patients. *Egyptian Journal of Anaesthesia*. 2023;39(1):266-76.
43. Gebregzabher S, Gebretensaye TG, Alemu T. Factors associated with major electrolyte disorders among post cardiac surgery patients at Tikur Anbessa Specialized Hospital and Cardiac Center Ethiopia in Addis Ababa, Ethiopia, 2021. *International Journal of Africa Nursing Sciences*. 2023;18:100556.
44. Pani A, Inglese E, Puoti M, Cento V, Alteri C, Romandini A, et al. Sex differences in electrolyte imbalances caused by SARS-CoV-2: A cross-sectional study. *International Journal of Clinical Practice*. 2021;75(12):e14882.
45. Schlanger LE, Bailey JL, Sands JM. Electrolytes in the aging. *Advances in chronic kidney disease*. 2010;17(4):308-19.
46. Luckey AE, Parsa CJ. Fluid and Electrolytes in the Aged. *Archives of Surgery*. 2003;138(10):1055-60.
47. Mandole M, Howale D, Mamatha M, Sharma D, Gamit D, Pandit D. Evaluation of renal function tests and serum electrolytes in patients with acute myocardial infarction. *Int J Biomed Res*. 2016;7(9):676-9.
48. Aziz A, Abdul-Hassan M, Mohammed K. Plasma atrial natriuretic peptide level and serum electrolyte status among patients with acute myocardial infarction complicated with cardiac arrhythmia. *Eur J Mol Clin Med*. 2020;7(2):4352-60.
49. Marshall DC, Saliccioli JD, Goodson RJ, Pimentel MA, Sun KY, Celi LA, et al. The association between sodium fluctuations and mortality in surgical patients requiring intensive care. *Journal of critical care*. 2017;40:63-8.
50. Longevity O. Retracted: Influence Factors and Predictive Models for the Outcome of Patients with Ischemic Stroke after Intravenous Thrombolysis: A Multicenter Retrospective Cohort Study. *Oxidative Medicine and Cellular Longevity*. 2024;2024:9813785-.
51. Ji R, Shen H, Pan Y, Wang P, Liu G, Wang Y, et al. Novel risk score to predict pneumonia after acute ischemic stroke. *Stroke*. 2013;44(5):1303-9.
52. Barlas RS, Honney K, Loke YK, McCall SJ, Bettencourt-Silva JH, Clark AB, et al. Impact of hemoglobin levels and anemia on mortality in acute stroke: analysis of UK regional registry data, systematic review, and meta-analysis. *Journal of the American Heart Association*. 2016;5(8):e003019.
53. Tinawi M. Pathophysiology, evaluation, and management of metabolic alkalosis. *Cureus*. 2021;13(1).
54. Buckley MS, Leblanc JM, Cawley MJ. Electrolyte disturbances associated with commonly prescribed medications in the intensive care unit. *Crit Care Med*. 2010;38(6 Suppl):S253-64.
55. Syed Z, Rahul B, Kainat S. Electrolytes in the ICU. In: Gyula M, Gonzalo D-S, editors. *Mineral Deficiencies*. Rijeka: IntechOpen; 2021. p. Ch. 9.
56. Mayerhöfer T, Shaw AD, Wiedermann CJ, Joannidis M. Fluids in the ICU: which is the right one? *Nephrology Dialysis Transplantation*. 2022;38(7):1603-12.
57. Abboud SK, Assad HC, Al-Jumaili AA. Pharmacist intervention to enhance postoperative fluid prescribing practice in an Iraqi hospital through implementation of NICE guideline. *Pharmacy Practice (Granada)*. 2019;17(3).
58. Sadeghi-Bojd S, Noori NM, Damani E, Teimouri A. Electrolyte disturbances in PICU: A cross sectional study. *Nephro-Urology Monthly*. 2019;11(2).
59. Biadgo B, Melak T, Ambachew S, Baynes HW, Limenih MA, Jaleta KN, et al. The prevalence of metabolic syndrome and its components among type 2 diabetes mellitus patients at a tertiary hospital, northwest Ethiopia. *Ethiopian journal of health sciences*. 2018;28(5).

60. Asaye S, Bekele S, Tolessa D, Cheneke W. Metabolic syndrome and associated factors among psychiatric patients in Jimma University Specialized Hospital, South West Ethiopia. *Diabetes & Metabolic Syndrome: Clinical Research & Reviews*. 2018;12(5):753-60.
61. Belay CM, Zewale TA, Amlak BT, Abebe TG, Hailu G. Incidence and Predictors of Ventilator-Associated Pneumonia Among Adult Intubated Patients in Bahir Dar Specialized Hospitals, 2021: A Retrospective Follow-Up Study. *International journal of general medicine*. 2022;15:8173-82.
62. Demass TB, Guadie AG, Mengistu TB, Belay ZA, Melese AA, Berneh AA, et al. The magnitude of mortality and its predictors among adult patients admitted to the Intensive care unit in Amhara Regional State, Northwest Ethiopia. *Sci Rep*. 2023;13(1):12010.
63. Seid MA, Adella GA, Kassie GA, Mengstie MA, Dejenie TA, Zemene MA, et al. Serum electrolyte imbalance in severely malnourished children at hospitals in North-central Ethiopia. 2023.
64. Ayhan YE, İlerler EE, Sosyal D, Bektay MY, Karakurt S, Daşkaya H, et al. Assessment of drug-induced electrolyte disorders in intensive care units: a multicenter observational study. *Frontiers in Medicine*. 2024;11:1343483.
65. Kurugod SG, Sreenivasa S. Treatment of Electrolyte Disorders in Adult Patients in the Intensive Care Unit (ICU).
66. Bender W, Hiddleson CA, Buchman TG. Intensive care unit telemedicine: innovations and limitations. *Critical care clinics*. 2019;35(3):497-509.
67. Arzapalo MA. Association of elevated levels of plasma chloride, in severity and mortality, in adult patients in the ICU. *Critical Care*. 2015;19(Suppl 1):P360.
68. Besen BA, Gobatto AL, Melro LM, Maciel AT, Park M. Fluid and electrolyte overload in critically ill patients: An overview. *World journal of critical care medicine*. 2015;4(2):116-29.
69. APRIL C. AN OFFICIAL JOURNAL of the AMERICAN HEART ASSOCIATION. *Circulation*. 1974;49.
70. Hayes W. Ab-normal saline in abnormal kidney function: risks and alternatives. *Pediatric nephrology (Berlin, Germany)*. 2019;34(7):1191-9.
71. Singh S, Kerndt CC, Davis D. *Ringer's Lactate*. 2018.

10. Annexes

Annex I: Information Sheet in English Version

Title of the Research: Electrolyte imbalance and associated factors in intensive care units patients of public hospitals, Bahir Dar ,Ethiopia, 2024.

Name of Investigator: Getu Gashaw

Name of the Organization: St Paul's Hospital Millennium Medical College school of Nursing

Introduction: this information sheet is prepared for Bahir Dar town public hospitals, Ethiopia. The aim of the form is to make the concerned office clear about the purpose of research, data collection procedures and get permission to conduct the research.

Purpose of the Research: To assess the Electrolyte imbalance and associated factors in the intensive care units patients of Bahir Dar Public Hospitals, Bahir dar, Ethiopia, 2024.

Risk and/or Discomfort: Since the study will conduct by taking appropriate information from medical chart, could not inflict any harm on the patients. The name or any other identifying information will not recorded on the questionnaire and all information taken from the chart kept strictly confidential and in a safe place. The information extracted will be kept secured by locking with key. After the data entry in to the computer it will be locked by password. The information retrieved used only for the study purpose.

Benefits: the research has no direct benefit for those whose document/ record that will be included in this research. However, the indirect benefit of the research for the participant and other clients in the program is clear. This is because if program planners are preparing predicted plan, there is a benefit for clients in the program of getting appropriate case specific care and treatment services for the common electrolyte imbalance and associated factors in the intensive care units patients. Of all, the research work has a paramount direct benefit for health care planners and managers, especially for those works in intensive care units association program planning and management

Confidentiality: to ensure confidentiality the data on the chart will be collected by those individuals who are health professionals working in the facility and information collected without the name of the clients. The information collected from this research project will be kept confidentially and will store in a file. In

addition, it will not be revealed to anyone except the investigator and it will be keep by key and locked system with computer password. The research project will be reviewed and approved by the research review committee of School of Nursing, St.PHMMC

Person to contact: If you have any question, you can contact the principal investigator.

Principal investigator address

Name: Getu Gashaw Adimas Phone: +251918599076 E-mail: getug2008@gmail.com

Annex II: Data Collection Tool/Questionnaire (English Version)

Questionnaire/checklist serial number_____

Name of the hospital_____

Name of data collector_____

Supervisor's Name_____

Date of data collection: DD__MM__YYYY_____

A questionnaire was prepared to assess the prevalence and associated factors of common electrolyte imbalances in the ICUs of Bahir Dar Comprehensive Specialized Hospital, Bahir Dar, Ethiopia, in 2024.

Part I: - Socio-demographic characteristics			
Serial no	Variable/Questions	Labels/response category	Remark
101	Age in years	_____	
102	Sex	1.male 2.female	
103	place of residence	1. Rural 2. Urban	
Part II: Clinical codtions			

201	Cause of admission	1.heart diseases 2.digestive diseases 3.orthopedic surgery 4. Respiratory diseases 5.DKA 6 Neurology 7. Renal 8. Surgical 9.others.....	
202	Had history of AKI ?	1.yes 2.no	
203	Had history of diabetes mellitus ?	1.yes 2.no	
204	Had history of CKD ?	1.yes 2.no	
Part III: Medications related Factors			
301	Diuretics	1.Yes 2.no	
302	If yes for question 301 which medication	a. Frusemide b. Thiazide c. Spironolactone	
303	Vasoactive	1.Yes 2.no	
304	If yes for question 303 which medication	a. Epinephrine b. Norepinephrine c. Dopamine	
305	Antibiotics	1. Yes 2. No	
306	Corticosteroids	1.yes 2.no	
307	Sedatives	1.yes 2.no	
308	Proton pump inhibitors	1.yes 2.no	

309	Antiplatelets and anticoagulants	1.yes 2.no	
310	If yes for question 309 which medction	a. Aspirin b. Heparin c. Warfarin	

Part IV: IV fluids and blood transfusion related Factors

401	NS	1.yes 2.no	
402	RL	1.yes 2.no	
403	D5W	1.yes 2.no	
404	Blood product Transfusion	1.yes 2.no	

Part V: lab parameters

501	Sodium (Meq/l)	_____	
502	Potassium (Meq/l)	_____	
503	Calcium (mg/dl)	_____	
504	Chloride (Meq/l)	_____	
505	Creatinine (Mg/dl)	_____	
506	Urea (mg/dl)	_____	
507	AST (IU/l)	_____	
508	ALT (IU/l)	_____	

509	ALP (IU/l)		
510	FBS		
600	Outcome	Disch arged/ Impro ved	
		Died	

Declaration

I declare that this Research thesis entitled " Electrolyte Imbalance and Associated Factors among Patients in Intensive Care Units of Public Hospitals, Bahir Dar, Ethiopia, 2024." is my own work that have not been addressed in the study area as far as my knowledge touched and all the sources I used has been indicated and acknowledged as complete reference.

Name of investigator

Signature

Date

Name of advisor(s)

1. _____

2. _____

Name of invigilators

1. _____

2. _____
