RENAL BIOCHEMICAL PARAMETERS, RISK FACTORS, & CARDIAC TROPONIN T LEVELS AMONG END-STAGE KIDNEY DISEASE PATIENTS UNDERGOING HAEMODIALYSIS AT JARAMOGI OGINGA ODINGA TEACHING & REFERRAL HOSPITAL, WESTERN KENYA

BY

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SCHOOL OF PUBLIC HEALTH AND COMMUNITY DEVELOPMENT

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DECLARATION

This thesis is my original work and has not been presented to any other university or institution for a degree or any other award.

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DEDICATION

This thesis is dedicated to the resilient patients battling end-stage kidney disease at Jaramogi Oginga Odinga Teaching Hospital, Western Kenya, whose unwavering perseverance amidst the challenges of treatment and illness exemplifies courage and determination. Their willingness to participate in this study, sharing their personal health experiences, has provided invaluable insights that will contribute to advancing our understanding of the complex interplay between cardiac health and kidney function. This work is also dedicated to the healthcare professionals who tirelessly care for these patients, often under difficult circumstances, and whose dedication to improving the quality of life for renal patients is deeply appreciated. Finally, it is dedicated to the hope that this research will play a role in improving clinical outcomes and the overall well-being of renal patients, not only in Kenya but globally.

ABSTRACT

End-Stage Kidney Disease (ESKD) is the terminal stage of chronic kidney disease (CKD) characterized by irreversible loss of kidney function requiring renal replacement therapy such as hemodialysis or kidney transplantation. Globally, CKD affects approximately 10% of the population, representing over 800 million individuals, with an estimated prevalence of 14% in sub-Saharan Africa and approximately 4% in Kenya. Cardiovascular complications remain the leading cause of morbidity and mortality among patients with ESKD. Cardiac Troponin T (cTnT), a sensitive biomarker of myocardial injury, is frequently elevated in ESKD patients; however, its relationship with renal biochemical parameters and associated risk factors remains poorly understood in resource-limited settings such as Western Kenya. The broad objective of this study was to determine the association between renal biochemical parameters, risk factors, and cardiac Troponin T levels among ESKD patients undergoing hemodialysis at Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH), Western Kenya. Specifically, the study assessed the association between demographic characteristics and renal biochemical parameters, established the relationship between renal biochemical parameters and cTnT levels, and evaluated risk factors associated with elevated cTnT levels. A cross-sectional descriptive study design was employed involving 71 ESKD patients selected through purposive sampling. Cardiac Troponin T levels were analyzed using Roche Cobas immunoassay analyzers, while renal biochemical parameters were measured using a Mindray chemistry analyzer with an ISE module. Descriptive statistics were used to summarize demographic and clinical characteristics, while Chi-square tests, Fisher's exact tests, and ordinal regression analyses were used to assess associations between variables at a significance level of $p < 0.05$. Ethical approval was obtained from the Institutional Scientific and Ethics Review Committee (ISERC) of JOOTRH and research authorization granted by NACOSTI. Among the participants, 50.7% were female and 49.3% were male. Elevated cTnT levels were observed in 98.6% of the participants. Age was not significantly associated with renal biochemical parameters ($p > 0.05$). However, gender demonstrated a statistically significant association with phosphorus levels (OR = 0.33, 95% CI: 0.11–0.98, $p = 0.042$). No statistically significant associations were observed between cTnT levels and creatinine ($p = 1.000$), urea ($p = 1.000$), sodium ($p = 0.410$), potassium ($p = 1.000$), calcium ($p = 1.000$), or phosphorus levels ($p = 1.000$). Chloride levels, however, showed a statistically significant association with cTnT levels ($p < 0.001$). Among the evaluated risk factors, frequency of dialysis sessions per week was significantly associated with elevated cTnT levels (OR = 6.36, 95% CI: 3.69–10.95, $p = 0.026$), while other comorbidities including hypertension, diabetes mellitus, HIV, cancer, and arthritis were not statistically significant. Elevated cTnT levels in ESKD, may be due to impaired renal function rather than an acute myocardial event, and clinicians should not automatically assume myocardial infarction based solely on troponin levels. This study reveals that gender has a noteworthy impact, specifically on phosphorus levels, indicating that men may be less likely to have elevated phosphorus compared to women. The significant finding with chloride underscores the importance of electrolyte management in ESKD patients and cardiovascular risk, and the potential benefits of increasing dialysis frequency to improve health outcomes. The study suggests the explore dynamics in elevated phosphorus level and gender specifically female to enhance understanding of the interplay between gender, phosphorous and cardiac health. Measure of chloride levels in CKD patients as a predictor of heart health. Future research focusing on the number of dialysis sessions to cardiovascular health outcomes in end-stage kidney disease (ESKD) patients.

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LIST OF ABBREVIATIONS AND ACRONYMS

ACS	Acute coronary syndromes
AKI	Acute Kidney Injury
AKD	Acute Kidney Disease
AMI	Acute Myocardiac Infarction
BMI	Body Mass Index
CAD	Coronary Artery Disease
cTn s	Cardiac Troponins
cTnT	Cardiac Troponin T
cTn I	Cardiac Troponin I
CVD	Cardiovascular disease
CKD	Chronic Kidney Disease
CKI	Chronic Kidney Injury
ESKD	End-Stage Kidney Disease
eGFR	estimated Glomerular Filtration Rate
JOOTRH	Jaramogi Oginga Odinga teaching and referral hospital
KD	Kidney Disease
NACOSTI	National Commission for Science Technology and Innovation
MI	Myocardiac Infarction

OPERATION DEFINATION OF TERMS

Calcium: Calcium ion is a mineral important for bone, nerve and muscle function .in renal failure, it is reduced due to phosphate retention and may affect cardiac contractility.

Cardiac Troponin: Is a protein found in heart muscle cells. High levels of troponin in the blood can be a sign that the heart has been under stress or has been injured in some way, even if a person doesn't have obvious symptoms.

Cardiac troponin T: Is a protein found in heart muscle cells. In the context of patients with kidney disease, especially those undergoing hemodialysis, elevated levels of cardiac troponin T may indicate that the heart is under stress or there is some level of heart damage, even if the patient isn't showing obvious symptoms.

Chloride: a major extracellular anion involves in acid -base balance,

Creatinine: is a waste product from muscle metabolism used to assess kidney function. It is a key marker of reduced glomerular filtration rate (GFR) and it indicates accumulation of waste due to impaired kidney function. High creatinine is also seen in reduced renal perfusion (poor cardiac output)

End-Stage Kidney disease (ESKD): is the final stage of kidney disease, where the kidneys are no longer able to work properly to filter waste and excess fluid from the blood. All patients with ESKD have CKD**,** because ESKD is the final stage of CKD. However, not all ESKD patients have CVD in the traditional sense.

Hemodialysis: Is a treatment that helps people whose kidneys are not working properly. It uses a machine to clean the blood by removing waste, excess fluid, and toxins that the kidneys would normally filter out.

Phosphorus: is a mineral involved in energy metabolism and bone formation, high values are related to renal failure that is reduced excretion that leads to bone disease and vascular calcifications, which worsen vascular stiffness and cardiac burden.

Potassium: a major intracellular electrolyte important for cardiac and muscle function. It is increased (hyperkalemia) due to impaired excretion and is a risk of arrhythmias. It is critical for cardiac electrical activity.

Sodium: a major extracellular electrolyte regulating fluid balance, which is one of the many functions of the kidney,

Urea: is an end product of protein metabolism excreted by the kidney .it is elevated in case of renal dysfunction, that is reduced excretion or dehydration. In heart failure high urea is seen in reduced renal blood flow and increased reabsorption

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CHAPTER ONE
INTRODUCTION

1.1 End-stage kidney disease, haemodialysis, and cardiovascular complications

End-stage kidney disease (ESKD) represents the terminal stage of chronic kidney disease (CKD), in which kidney function is irreversibly lost and patients require renal replacement therapy (RRT), such as dialysis or kidney transplantation, for survival (KDIGO, 2023). Over the past two decades, there has been a growing global recognition of increasing cases of ESKD requiring RRT, particularly in low- and middle-income countries (LMICs), where healthcare systems face significant resource constraints (Fiseha & Osborne, 2023). Kidney disease is defined by markers of kidney damage (structural criteria) and/or reduced estimated glomerular filtration rate (eGFR) (functional criteria), persisting for less than 3 months in acute kidney disease (AKD) and more than 3 months in CKD, as outlined by kidney disease: Improving Global Outcomes (KDIGO) guidelines (KDIGO, 2012).

Renal biochemical parameters, including urea, creatinine, sodium, potassium, calcium, phosphate, and chloride, are essential in the diagnosis and monitoring of kidney dysfunction (KDIGO, 2023). In patients with ESKD undergoing hemodialysis, biochemical derangements such as elevated serum urea and creatinine, hyperkalemia, hypocalcemia, and disordered phosphate metabolism are common. These abnormalities contribute to cardiovascular complications through mechanisms such as electrolyte imbalance, vascular calcification, and left ventricular hypertrophy (Wanner *et al.*, 2022). The interplay between renal dysfunction and cardiovascular disease is best understood through the concept of the cardiorenal syndrome, in which dysfunction of the kidneys and heart is bidirectionally linked through hemodynamic, neurohormonal, and inflammatory pathways.

In ESKD, reduced renal clearance leads to accumulation of uremic toxins, chronic volume overload, and activation of the renin–angiotensin–aldosterone system (RAAS) and sympathetic nervous system, all of which promote myocardial remodeling and left ventricular hypertrophy.

Disturbances in calcium–phosphate metabolism further accelerate vascular calcification and arterial stiffness, increasing cardiac workload and ischemic risk ((KDIGO, 2012; Rangaswami *et al.,* 2019; Wanner *et al.,* 2022). Additionally, chronic inflammation and oxidative stress contribute to endothelial dysfunction and atherosclerosis. These processes result in both overt cardiovascular disease and subclinical myocardial injury, often reflected by persistently elevated cardiac troponin T (cTnT) levels in dialysis patients, even in the absence of acute coronary syndromes (DeFilippi *et al.,* 2022; House *et al.,* 2023; Rangaswami *et al.,* 2019; Wanner *et al.,* 2022). Globally, CKD affects approximately 10% of the population, representing over 800 million individuals, with a rising burden in LMICs (Fiseha & Osborne, 2023).

In sub-Saharan Africa, the prevalence of CKD is estimated at approximately 14%, while in Kenya it is reported to be around 4%, with similar estimates observed in western Kenya (Maritim *et al.,* 2022). The increasing prevalence of CKD and ESKD is largely driven by the growing burden of diabetes mellitus, hypertension, obesity, and population aging (Fiseha & Osborne, 2023). Dialysis is a life-sustaining form of RRT that partially replaces kidney function but does not cure the disease. The main modalities include hemodialysis, peritoneal dialysis, and hemodiafiltration, with hemodialysis being the most widely used globally, accounting for the majority of dialysis cases (Bello *et al.,* 2022).

In Kenya, access to hemodialysis has improved significantly following government support, particularly through the National Hospital Insurance Fund (NHIF), which has expanded coverage for outpatient dialysis services and increased availability in county hospitals (Maritim *et al.,* 2022).Despite these advances, patients with CKD and especially those with ESKD remain at markedly increased risk of cardiovascular disease (CVD), which is the leading cause of morbidity and mortality in this population. It is estimated that up to 50% of patients with advanced CKD develop CVD, accounting for approximately 40–50% of deaths (Jankowski *et*

al., 2021). Among patients on hemodialysis, CVD affects more than two-thirds, and outcomes remain poor despite improvements in dialysis care (Bello *et al.,* 2022).

In Kenya, coronary heart disease contributes significantly to national mortality, accounting for approximately 4.5% of total deaths (World Health Organization [WHO], 2020). Cardiovascular biomarkers play an essential role in the detection of myocardial injury and risk stratification. These include cardiac troponins (cTnI and cTnT), B-type natriuretic peptide (BNP), N-terminal proBNP (NT-proBNP), creatine kinase-MB (CK-MB), and myoglobin (Collet *et al.,* 2021). Among these, cardiac troponin T (cTnT) is considered the gold standard for diagnosing myocardial injury due to its high sensitivity and specificity for cardiomyocyte damage (Collet *et al.,* 2021). However, interpretation of cTnT levels in patients with ESKD remains challenging, as elevated levels may reflect both reduced renal clearance and ongoing subclinical myocardial injury rather than acute coronary events (DeFilippi *et al.,* 2022; Sandoval *et al.,* 2020). This diagnostic ambiguity complicates clinical decision-making and underscores the need for contextual interpretation of troponin levels in dialysis populations. Although elevated cTnT levels have been strongly associated with increased cardiovascular events and mortality in CKD and dialysis patients, there remains limited data on their relationship with renal biochemical parameters, particularly in resource-limited settings such as Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH) in western Kenya. Understanding these associations is critical for improving risk stratification and guiding integrated cardiorenal management in this vulnerable population.

Elevated cTnT levels have been consistently associated with adverse clinical outcomes, including increased mortality, among patients with chronic kidney disease (CKD) and ESKD. Despite the global recognition of cardiovascular disease as the primary cause of mortality in ESKD patients, local data from Kenyan hemodialysis population remains unclear. Most clinical decisions in health facilities rely on renal biochemical monitoring (MOH/WHO)

without in cooperating cardiac biomarkers. This may result in under-diagnosis of myocardial injury and missed opportunity for early intervention. Studying the association between renal biochemical parameters and cardiac troponin T levels in this population will bridge an important knowledge gap. In addition, understanding demographics and clinical risk factors associated with elevated cTnT levels, may allow for improved cardiovascular risk stratification, tailored treatment, and ultimately better patient outcome.

1.2 Statement of the Problem

End-Stage Kidney Disease (ESKD) is a critical condition characterized by the irreversible loss of kidney function, often requiring haemodialysis as a treatment. While haemodialysis effectively addresses kidney failure, it has been associated with various cardiovascular complications, and patients with ESKD on haemodialysis in Kenya are at a high risk of cardiovascular morbidity and mortality. Cardiac troponin T, a sensitive marker of myocardial injury is frequently elevated in this group, but its clinical interpretation is confounded by renal dysfunction. following standard MOH/WHO recommended health poly guideline, cardiac biomarker monitoring is not routinely performed, and its relationship with renal biochemical parameters has not been adequately studied. This limits the clinicians' ability to accurately stratify cardiovascular risk, contributing to preventable morbidity and mortality in dialysis patients

1.3 Objectives

1.3.1 Broad Objective

To determine the association between renal biochemical parameters, risk factors and cardiac troponin T levels among End-stage renal disease patients undergoing haemodialysis at Jaramogi Oginga Odinga Teaching Hospital, Western Kenya.

1.3.2 Specific Objective

1. To determine the associations between demographic characteristics and renal biochemical parameters among End-stage renal disease patients undergoing haemodialysis at Jaramogi Oginga Odinga Teaching Hospital, Western Kenya.
2. To establish the associations between the renal biochemical parameters and cardiac Troponin T Levels among End-stage renal disease patients undergoing haemodialysis at Jaramogi Oginga Odinga Teaching Hospital, Western Kenya.
3. To assess the risk factors associated with cardiac Troponin T Levels among End-stage renal disease patients undergoing haemodialysis at Jaramogi Oginga Odinga Teaching Hospital, Western Kenya.

1.4 Hypotheses

Ho_1: There were no significant differences in the associations between demographic characteristics and renal biochemical parameters among End-stage renal disease patients undergoing haemodialysis at Jaramogi Oginga Odinga Teaching Hospital, Western Kenya.

Ho_2: There were no significant differences in the associations between the renal biochemical parameters and cardiac Troponin T Levels among End-stage renal disease patients undergoing haemodialysis at Jaramogi Oginga Odinga Teaching Hospital, Western Kenya.

Ho_3: There was no significant difference in the risk factors associated with cardiac Troponin T Levels among End-stage renal disease patients undergoing haemodialysis at Jaramogi Oginga Odinga Teaching Hospital, Western Kenya.

1.5 Conceptual Framework

The dependent variable in this study was to establish the levels of cardiac troponin T among the ESKD patients undergoing dialysis. The study intended to determine if the cardiac troponin T levels are deranged or within the reference ranges. The independent variable in the study were the gender, and age of ESKD patients undergoing dialysis at JOOTRH as shown in figure 1.1. The confounding variables among the ESKD patients included the presence of comorbidities as either hypertension, diabetes, HIV, cancer, arthritis.

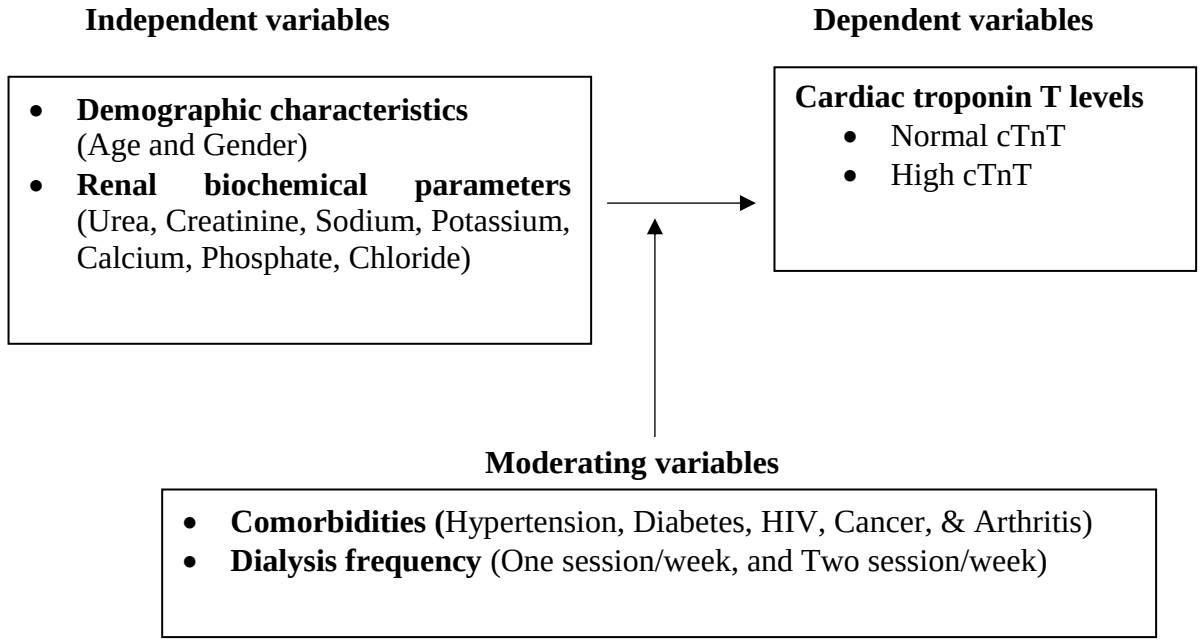


Figure 1.1: Conceptual framework

1.6 Study Limitations and De-Limitations

1.6.1 Limitations

The study's exclusive focus on Cardiac Troponin T levels could have overlooked other important cardiac biomarkers like CK-MB or BNP, which could provide additional insights into the extent and type of myocardial injury in ESKD patients.

2. By excluding other diagnostic methods such as ECG findings or additional biomarkers, the study may fail to fully capture the complexity of cardiac injury or the broader spectrum of cardiovascular risks in ESKD patients.

1.6.2 Delimitations

i. The study deliberately focused on Cardiac Troponin T levels, narrowing the scope to this specific biomarker in relation to cardiovascular risk in ESKD patients. This focus allows for an in-depth investigation into the role of Troponin T, making the findings more precise within this defined context, though it may not fully capture all potential markers of cardiac injury.

ii. The study excluded other diagnostic methods, such as CK-MB, BNP, or ECG findings, to maintain a focused approach on Cardiac Troponin T. This delimitation ensures a more targeted and specific analysis, reducing the complexity of the study but also limiting the ability to capture the full range of cardiovascular risks in the ESKD population.

CHAPTER TWO
LITERATURE REVIEW

2.1 Demographic Characteristics and Renal Biochemical Parameters in End-Stage Kidney Disease Patients Undergoing hemodialysis

Kidney Disease Outcomes Quality Initiative (KDOQI) Clinical Practice Guidelines for Chronic Kidney Disease, 2007 published guidelines by the Kidney Disease Outcomes Quality Initiative (KDOQI), which provided comprehensive data on demographic characteristics, such as age, gender, and comorbidities like hypertension and diabetes, in patients undergoing hemodialysis globally. The Clinical Practice Guidelines for Chronic Kidney Disease, 2007 emphasized on the biochemical parameters associated with ESKD, such as elevated creatinine, urea, potassium, and calcium imbalances. However, it is worth noting that the Clinical Practice Guidelines for Chronic Kidney Disease, 2007 focused on general guidelines and did not provide region-specific details or a deep analysis of how specific demographic factors influence biochemical parameters across different healthcare settings. Vanholder *et al.*, (2003), explored the biochemical parameters in dialysis patients, specifically focusing on urea and creatinine clearance as markers of renal function. He found that elevated serum creatinine and urea levels were common in patients on dialysis, and these biochemical markers were inversely related to patient survival rates. While he did a comprehensive biochemical analysis, the study did not examine the broader demographic variables such as gender, age, and socio-economic factors that could influence these biochemical markers in diverse populations.

Brouwer *et al.*,(2005) investigated the influence of age and comorbidities (e.g., hypertension and diabetes) on renal biochemical parameters in ESKD patients globally. The study concluded that comorbid conditions significantly affect biochemical markers like potassium, calcium, and phosphate. However, he did not account for regional differences in healthcare infrastructure or the socio-economic conditions that may impact dialysis outcomes in low- and middle-income countries like Kenya. This gap will be addressed in the current study by exploring the

demographic factors in the specific Kenyan context. Liano *et al.*, (2014), analyzed the impact of demographic factors, including age and gender, on kidney function and biochemical parameters such as phosphate and potassium levels in patients undergoing dialysis. In their study, Liano *et al.,* (2014), highlighted the importance of gender in predicting dialysis outcomes, with females showing higher levels of some renal biochemical markers. Although Liano *et al.,* (2014), mentioned gender differences, it did not explore regional differences or the impact of specific contextual factors in African populations. The current study will address the gap by focusing on the Kenyan population, where gender and socio-economic factors may differ.

Munyasi *et al.,* (2017), conducted in Uganda, assessed the demographic and biochemical parameters of ESKD patients undergoing hemodialysis. It identified common biochemical markers like high serum creatinine, potassium, and phosphate levels, while highlighting the effects of hypertension and diabetes as prevalent comorbidities. While Munyasi *et al.*, (2017), provided useful insights into the relationship between comorbidities and renal biochemical parameters, it did not delve deeply into the socio-economic factors or the rural-urban divide in Uganda. This gap will be addressed by the current study by exploring such variables in Kenya. Kwofie *et al.*, (2016), from Ghana focused on the prevalence of hypertension and diabetes in dialysis patients, as well as its impact on renal biochemical parameters such as serum potassium, calcium, and creatinine. The study found that patients with both hypertension and diabetes showed significantly worse biochemical parameters. Kwofie *et al.,* (2016), did not assess other demographic factors such as age, gender, and occupation, which could also impact the biochemical parameters. The current study will address this gap by including a more comprehensive demographic analysis in the Kenyan setting.

Chijioke *et al.*, (2015), in South Africa investigated renal biochemical markers such as serum calcium, phosphate, and creatinine in dialysis patients, while also considering demographic data such as age and gender. Chijioke *et al.,* (2015), found a correlation between increased age and worsened renal function. Chijioke *et al.,* (2015), did not provide a comparison of rural and urban settings, and it focused primarily on age and gender without considering the role of socio-economic status. This gap will be addressed in the current study, which will focus on diverse demographic variables, including urban-rural differences.

Munyasi *et al.,* (2016), conducted a study in Nairobi, Kenya, evaluated the prevalence of comorbidities like hypertension and diabetes among ESKD patients. Munyasi *et al.,* (2016), also examined renal biochemical markers like creatinine, potassium, and urea, finding high levels of these markers in dialysis patients. Although Munyasi *et al.,* (2016), focused on biochemical parameters, it did not explore the relationship between demographic variables like age, gender, and socio-economic status on the biochemical markers in Kenyan dialysis patients. The current study will fill this gap by including a detailed demographic breakdown. Kiguli *et al.,* (2018), conducted a study in Nairobi focused on the effects of comorbidities, particularly hypertension and diabetes, on renal function and biochemical parameters in dialysis patients. Elevated levels of creatinine and urea were common in patients with these comorbidities. Kiguli *et al.,* (2018), primarily focused on clinical and biochemical parameters, leaving out socio-economic factors such as income and healthcare access. The current study will address this gap by evaluating the role of socio-economic variables in the progression of ESKD.

Chien *et al.,* (2015), conducted a study in Kenyan to explore the biochemical parameters, such as potassium, calcium, and phosphate, in patients undergoing dialysis. Chien *et al.*, (2015), found significant imbalances in these parameters, but did not explore the impact of gender and age in relation to biochemical outcomes. Chien *et al.,* (2015), did not explore the influence of

demographic factors like gender and age in relation to renal biochemical parameters. The current study will fill this gap by integrating both demographic characteristics and renal parameters in Kenyan patients. Omondi *et al.,* (2019), conducted a study in Kisumu, Kenya, examined the impact of gender, age, and coexisting conditions like hypertension and diabetes on the renal biochemical markers in dialysis patients. The study highlighted the role of age and gender but lacked in-depth analysis of how different biochemical markers interact with each other. While Omondi *et al.,* (2019), considered gender and age, it did not perform a thorough analysis of the interaction between these factors and their collective impact on kidney function. The current study will address this gap by applying advanced analytical methods to explore these interactions.

2.2 Associations between the Renal Biochemical Parameters and Cardiac Troponin T Levels in End-Stage Kidney Disease Patients Undergoing Hemodialysis

In their study, Luca *et al.,* (2018) explored the relationship between cardiac biomarkers, including cardiac Troponin T (cTnT), and renal biochemical parameters in patients with End-Stage Kidney Disease (ESKD) undergoing hemodialysis. Luca *et al.,* (2018) observed significant associations between elevated cTnT levels and poor renal function markers, including increased serum creatinine and urea, suggesting a correlation between myocardial injury and worsening kidney function. Luca *et al.,* (2018) primarily focused on Western populations, and did not explore how demographic variables (such as age, gender, and ethnicity) and contextual factors like access to healthcare affect these relationships in low-resource settings like Kenya.

Ravikumar *et al.,* (2017) investigated the correlation between cTnT levels and renal parameters (e.g., potassium, creatinine, phosphate) in hemodialysis patients. Ravikumar *et al.,* (2017), findings showed that elevated cTnT levels are predictive of cardiovascular events and are associated with renal dysfunction. Ravikumar *et al.,* (2017), did not delve into regional differences, especially between urban and rural populations, or examine how specific socio-

economic conditions influence the cTnT-renal function relationship, which is a gap the current study seeks to address in the Kenyan context. A study by Olivier *et al.,* (2019) found that elevated cardiac troponin levels were associated with poorer renal biochemical markers such as creatinine and urea in hemodialysis patients. Olivier *et al.,* (2019) highlighted the role of myocardial injury in worsening renal outcomes in the ESKD population. Although Olivier *et al.,* (2019) demonstrated the link between myocardial injury and renal dysfunction, it did not investigate potential confounding variables like hypertension, diabetes, and other comorbidities. These factors will be analyzed in the Kenyan context in the current study to identify additional influences on these biomarkers.

Vikram *et al.,* (2021) examined the link between cTnT levels and renal biochemical parameters in hemodialysis patients, finding that elevated cTnT levels were associated with high serum creatinine and potassium. Vikram *et al.,* (2021) focused on how these biomarkers correlate with heart disease progression in dialysis patients. However, Vikram *et al.,* (2021), was based on a single center and lacked multi-center data, limiting its generalizability. The current study, with a larger sample size across various regions in Kenya, will address this gap by providing a broader and more contextually relevant understanding of the associations between these biomarkers.

Munyasi *et al.,* (2017), study in Uganda explored the relationship between renal biochemical parameters and cardiac biomarkers in ESKD patients on hemodialysis. Munyasi *et al.,* (2017), found significant associations between elevated creatinine levels and high cTnT concentrations, indicating myocardial injury and poor renal function. Munyasi *et al.,* (2017), did not address how factors such as ethnicity, rural-urban divide, and access to healthcare resources impact these associations. The current study will investigate these factors in Kenya, providing more nuanced insights.

Kwofie *et al.,* (2016), Ghana-based study explored the biochemical markers and the relationship between renal dysfunction and cardiac injury in dialysis patients. It identified a strong correlation between elevated cTnT levels and worsening biochemical markers such as creatinine and potassium in dialysis patients. However, Kwofie*et al.,* (2016), did not explore the interplay between multiple demographic factors and how they influence renal function and cTnT levels. The current study will address this by conducting a comprehensive analysis of demographic characteristics in Kenya. Zhou *et al.,* (2020) studied the impact of elevated cardiac Troponin T levels on renal biochemical parameters in Chinese hemodialysis patients, finding that high cTnT levels were associated with increased serum creatinine and phosphate. Zhou *et al.,* (2020), lacked focus on the rural-urban disparity and socio-economic factors that could influence both kidney function and myocardial injury in different populations. The current study will address this gap in the Kenyan setting.

Munyasi *et al.,* (2016) examined the relationship between renal biochemical parameters (serum creatinine, urea, potassium) and cardiac biomarkers (including cTnT) in dialysis patients in Nairobi. The study found that elevated cTnT was associated with poor renal function. Munyasi *et al.,* (2016) focused on biochemical markers, it did not consider other important factors, such as the impact of socio-economic variables (income, education) and health access on the levels of cTnT and kidney function. The current study will incorporate these factors to better understand their impact. Kiguli *et al.,* (2018), in Nairobi, found significant correlations between elevated cTnT levels and renal dysfunction, as evidenced by high serum creatinine and urea levels. Kiguli *et al.,* (2018), highlighted the predictive value of cTnT in assessing cardiovascular risk in dialysis patients. However, Kiguli *et al.,* (2018), did not explore the demographic characteristics of the population comprehensively, such as the role of gender, age, and occupation. The current study will expand the scope to include these demographic factors.

Chien *et al.,* (2015) explored the renal biochemical parameters and their association with elevated cardiac biomarkers, including cTnT, in dialysis patients in Kenya. Chien *et al.,* (2015) found a relationship between renal dysfunction and elevated cTnT levels but did not analyze the effects of comorbidities like hypertension and diabetes. The current study will address this by looking at the interaction between cTnT and comorbidities such as hypertension and diabetes, and how these impact renal biochemical markers in the Kenyan setting. Omondi *et al.,* (2019) in Kisumu, Kenya, examined the correlation between demographic factors, comorbidities, and renal biochemical markers in dialysis patients. Omondi *et al.,* (2019) noted the significant impact of age and gender but did not fully analyze the relationship between these factors and cTnT levels. The current study will fill this gap by conducting a detailed statistical analysis of the interactions between demographic factors and cTnT levels, with a focus on the rural-urban differences in Kenya.

2.3 Risk factors associated with cardiac Troponin T Levels in End-Stage Kidney Disease Patients Undergoing Hemodialysis

Zhao et *al.,* (2017) conducted a study in China that examined the risk factors associated with elevated cardiac Troponin T (cTnT) levels in End-Stage Kidney Disease (ESKD) patients undergoing hemodialysis. Zhao et *al.,* (2017) found that comorbidities such as hypertension, diabetes, and coronary artery disease were significant risk factors for elevated cTnT levels in these patients. Although Zhao et *al.,* (2017) identified key risk factors, it was limited to a single center and did not address socio-economic and demographic factors that might influence these associations. The current study will fill this gap by considering broader demographic characteristics and regional factors in Kenya. Meyer *et al.,* (2015) focused on the relationship between cardiac Troponin T and various risk factors in dialysis patients in the United States. Meyer *et al.,* (2015, highlighted the role of comorbidities such as diabetes, heart failure, and hypertension in increasing cTnT levels. The researchers also noted the significance of aging

and gender in influencing these levels. While Meyer *et al.,* (2015) explored various comorbidities, it did not explore the socio-economic conditions or access to healthcare as potential risk factors. The current study will include these variables to better understand the risks in the Kenyan context.

Legrand *et al.,* (2018) explored the association between elevated cTnT levels and clinical risk factors in dialysis patients. Legrand *et al.,* (2018) found that the most significant factors were diabetes, history of myocardial infarction, and hypertension. Legrand *et al.,* (2018) suggested that cTnT levels could be used to predict cardiovascular events in ESKD patients undergoing hemodialysis. While comprehensive in clinical risk factors, Legrand *et al.,* (2018) did not assess the impact of demographic factors like age, gender, and socio-economic status. The current study will examine these factors more thoroughly in the Kenyan context. Martínez *et al.,* (2019), conducted a global review of risk factors for elevated cTnT levels in hemodialysis patients, identifying comorbidities like diabetes, chronic hypertension, and coronary artery disease as primary risk factors. Martínez *et al.,* (2019), also examined how advanced age and the duration of dialysis contributed to higher cTnT levels. Despite its broad scope, Martínez *et al.,* (2019), did not focus on rural-urban disparities in healthcare access, which could influence the prevalence of cTnT elevation in ESKD patients. The current study will address this gap by considering the rural-urban divide in Kenya.

Munyasi *et al.,* (2016), conducted a study in Uganda examining risk factors for elevated cardiac biomarkers, including cTnT, in hemodialysis patients. Munyasi *et al.,* (2016), identified diabetes and hypertension as the most significant contributors to increased cTnT levels, alongside male gender and older age. Munyasi *et al.,* (2016), did not consider the role of socio-economic status or healthcare accessibility in influencing cTnT levels, which is a gap the current study will address by including these factors in the Kenyan context. Kwofie *et al.,*

(2017), conducted a Ghana-based study found that elevated cTnT levels were strongly associated with comorbidities such as hypertension and diabetes in dialysis patients. Kwofie *et al.,* (2017), also noted that dialysis duration and age were key risk factors. However, Kwofie *et al.,* (2017), did not explore the impact of regional and socio-economic factors such as income, occupation, and access to health services. The current study will fill this gap by exploring these additional factors in Kenya.

Ibrahim *et al.,* (2012) studied the risk factors for elevated cTnT levels in dialysis patients in Nigeria. Ibrahim *et al.,* (2012) found a significant association between hypertension, diabetes, and coronary artery disease, and elevated cTnT levels. Ibrahim *et al.,* (2012) focused on clinical factors but did not explore socio-economic determinants such as healthcare access, income, and education. The current study will address these factors to provide a more comprehensive understanding of the risk factors for elevated cTnT in Kenya. Chijioke *et al.,* (2015), conducted a study in South Africa that found a significant association between elevated cTnT levels and cardiovascular comorbidities like hypertension and diabetes. The study also noted that older age was a contributing factor. However, Chijioke *et al.,* (2015), did not analyze how demographic factors like gender and socio-economic status influenced cTnT levels. The current study will provide a more in-depth exploration of these factors in the Kenyan population.

Munyasi *et al.,* (2016), explored the risk factors for elevated cTnT levels in dialysis patients in Nairobi, Kenya. Munyasi *et al.,* (2016), identified hypertension, diabetes, and older age as major contributors to elevated cTnT levels. Munyasi *et al.,* (2016), did not include a detailed demographic analysis or explore the influence of rural-urban differences, which are significant factors in Kenya. The current study will address this gap by considering rural-urban disparities.

Kiguli *et al.,* (2018), studied the impact of comorbidities, particularly diabetes and hypertension, on the cTnT levels in dialysis patients in Nairobi. Kiguli *et al.,* (2018), found that diabetes and hypertension were key risk factors for myocardial injury in these patients. Kiguli *et al.,* (2018), did not explore the influence of socio-economic factors or access to healthcare on cTnT levels. The current study will address this gap by including socio-economic variables and exploring healthcare access as additional risk factors.

Omondi *et al.,* (2019) examined risk factors for elevated cTnT levels in dialysis patients in Kisumu, Kenya, and found that comorbidities such as hypertension and diabetes were associated with increased cTnT levels. Omondi *et al.,* (2019) lacked a comprehensive analysis of the impact of age, gender, and socio-economic status on cTnT levels. The current study will fill this gap by including a detailed demographic breakdown and considering rural-urban differences. Chien *et al.,* (2015) studied risk factors for elevated cardiac biomarkers, including cTnT, in dialysis patients in Nairobi, Kenya. Chien *et al.,* (2015) found that hypertension and diabetes were major risk factors for elevated cTnT levels in these patients. Chien *et al.,* (2015), did not explore the effects of socio-economic variables like income, occupation, or education. The current study will address these gaps by analyzing the socio-economic factors influencing cTnT levels in Kenyan dialysis patients.

CHAPTER THREE
MATERIALS AND METHODS

3.1 Study Area

The study was conducted at Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH), one of the largest teaching and referral hospitals in the region. JOOTRH serves a diverse population from Western Kenya as well as parts of the South Rift, offering specialized medical services and training opportunities. Western Kenya (Figure 3.1) is geographically bordered to the southwest by Tanzania and to the west by Uganda. The region is comprised of nine counties: Migori, Homa Bay, Kisumu, Vihiga, Busia, Kakamega, Bungoma, Siaya, and Nyamira. Spanning a total area of 17,750 square kilometers, the region is home to a population of 9,620,852 people. Of this population, 4,208,521 are male, representing 43.74% of the total population, while 5,412,331 are female, accounting for 56.26%.

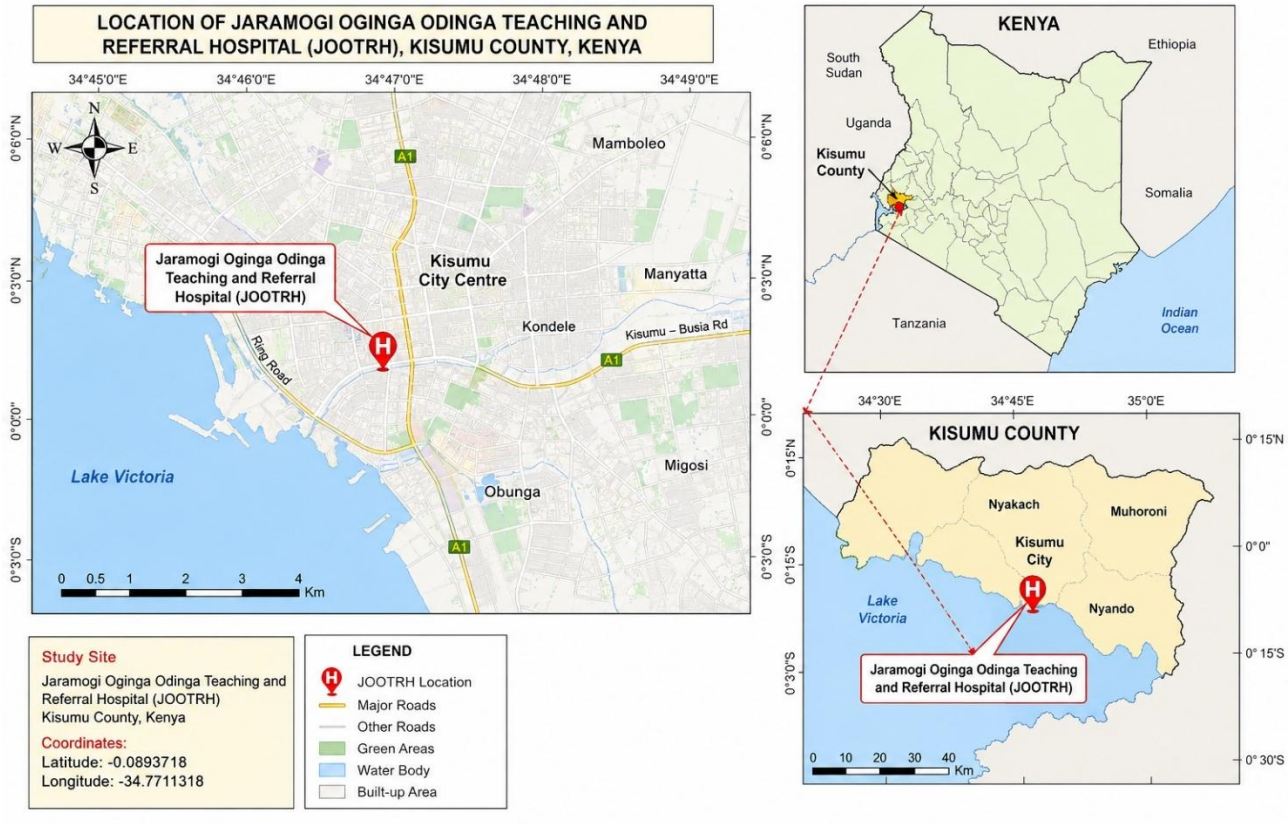


Figure 3.1: Location of Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH) in Kisumu County

3.2 Study Design

This study was a cross-sectional descriptive research design, specifically aimed at investigating patients with End-Stage Kidney Disease (ESKD) who were undergoing hemodialysis at Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH). The study sought to gather detailed information about this patient population at a single point in time, providing a snapshot of their medical conditions and treatment outcomes.

3.3 Study Population

The study enrolled prospective patients diagnosed with End-Stage Kidney Disease (ESKD) who were aged 18 years and above and undergoing regular hemodialysis at the renal unit of Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH). Patients younger than 18 years were excluded, as were those with a history of acute myocardial infarction, heart failure, or pulmonary embolism within the preceding six months. A total of 71 patients were initially screened for eligibility.

3.4 Inclusion and Exclusion Criteria

3.4.1 Inclusion Criteria

The inclusion criteria for this study required participants to be adults diagnosed with End-Stage Kidney Disease (ESKD) and were actively undergoing dialysis treatment at Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH). Additionally, all participants were required to provide informed consent, ensuring that they voluntarily agreed to take part in the study with a full understanding of its purpose, procedures, and potential risks.

3.4.2 Exclusion Criteria

The exclusion criteria for this study included patients with a history of acute myocardial infarction (heart attack), heart failure, or pulmonary embolism within the last 6 months, as these conditions could complicate the study results and pose additional health risks. Pregnant women were excluded due to the potential risks associated with dialysis during pregnancy. These criteria were implemented to ensure the safety of the participants and the validity of the study outcomes.

3.5 Sampling Technique

The study employed purposive sampling to selectively enroll patients diagnosed with End-Stage Kidney Disease (ESKD) who met the inclusion criteria. Participants were chosen based on specific characteristics relevant to the study, and enrollment continued until the target sample size of 71 patients was reached. This method ensured that the sample consisted of individuals who were most appropriate for addressing the study's research objectives.

3.6 Sample Size Determination

The sample size was be determined using the Taro Ya mane formula of 1967. The statistical formula devised by Taro Ya mane is as follows: $n = N/ (1+N (e)^2)$

In the formula above; n is the required sample size from the population under study, N is the whole population that is under study (85), e is the precision or sampling error which is usually 0.05. Therefore $n=85/ (1+85(0.05)^{2)}$

$$n= 85/ 1+85 (0.0025)$$

$$n = 85/ (1+0.2125)$$

$$n = 85/ 1.2125$$

$$n = 70.1030$$

n = approximately 71 participants.

3.7 Laboratory Analysis

3.7.1 Biodata of ESKD patients undergoing hemodialysis

A paper-based data collection form was used to obtain biodata from patients with End-Stage Kidney Disease (ESKD) undergoing hemodialysis. The form was designed to collect demographic information such as age and gender, as well as relevant clinical information including patient medical history and the presence of comorbidities. The collected information provided a comprehensive overview of the participants' characteristics and assisted in contextualizing the study findings. Information was obtained through patient interviews and review of medical records.

3.7.2 Sample Collection

Peripheral whole blood (3-5 mL) was drawn from the participants and collected into vacutainer serum separation tubes (SST) without any additives. The blood was left to clot, and the serum was subsequently separated by centrifugation at 2000 rpm for 10 minutes at room temperature, all within 3 hours of collection. The resulting serum was then aliquoted into 2 mL portions for use in subsequent assays. The serum was utilized within 24 hours of collection, stored at room temperature. Any remaining samples were frozen at -20°C for future analysis. To maintain participant confidentiality, all collected samples were assigned unique codes that ensured the identities of the participants were not disclosed.

3.7.3 Renal Biochemical Measurements

Renal biochemical parameters were measured using a Mindray machine with an ISE module (Roche Diagnostics). Prior to running test samples, control sera were run to ensure the values were within the range. Sample tubes containing 2 mL of serum were placed in the rack area, which could be accessed by opening the rack access panel. This panel housed both the cassette and sample rack areas. The machine's display screen identified the sample by its unique sample ID, allowing for accurate sample tracking. The screen also showed all active tests, profiles, and ratios. Parameters such as sodium, potassium, chloride, urea, creatinine, phosphate, and calcium were selected for testing. Samples were placed in the sample areas within 10 seconds after the test selection was confirmed on an available position in the sample rack. The system registered the sample's location and associated it with the corresponding order.

The testing process began when the action button was pressed. The system first verified that there were enough cuvettes and that all necessary reagents were present on the reagent disk. Measurements were then recorded by the computer system, which calculated the results and stored the data in a database on the data station computer's hard disk. The system automatically flagged any results that did not meet the required specifications. All measurements were cross-referenced with standard reference values, as outlined in the standard operating procedure

(SOP) for renal parameter measurement at JOOTRH (SOP No JOOTRH-1000-006P, Version 1, Appendix V). The reference ranges for serum creatinine were 45-120 µmol/L for males and 40-107 µmol/L for females, urea was 2.5-7.5 mmol/L for males and 2.0-7.0 mmol/L for females, potassium was 3.5-5.5 mmol/L, sodium was 135-155 mmol/L, total calcium was 2.2-2.65 mmol/L, phosphorus was 0.8-1.45 mmol/L, and serum chloride was 98-107 mmol/L for males and 96-108 mmol/L for females.

3.7.4 Cardiac Troponin T assay

Cardiac troponin T (cTnT) levels were measured using the electrochemiluminescence immunoassay (ECLIA) technique on the Roche Elecsys and Cobas e immunoassay analyzers. This method is widely used in clinical chemistry because it is highly sensitive and specific for detecting even very low concentrations of cardiac muscle injury markers in blood.

3.7.4.1 Troponin T measurements

Cardiac troponin T (cTnT) levels were measured using the electrochemiluminescence immunoassay (ECLIA) method on the Roche Elecsys and Cobas e immunoassay analyzers. The assay is based on a sandwich immunoassay principle, where patient serum (50 µL) is incubated with biotinylated and ruthenium-labeled monoclonal antibodies specific to cardiac troponin T, forming antigen–antibody complexes. Streptavidin-coated magnetic microparticles are then added to bind the complexes, which are subsequently captured on a magnetic electrode surface. After washing to remove unbound substances, a voltage is applied to induce chemiluminescent emission, which is measured by a photomultiplier. The emitted signal is directly proportional to the concentration of troponin T in the sample and is quantified using a calibration curve generated by the analyzer. The assay has a measurement range of 3–10,000 ng/L, with a reference (normal) value of 0–14 ng/L in asymptomatic individuals

3.7.4.2 Interpretation of Troponin Levels in the Blood

Cardiac troponin T (cTnT) concentrations were reported in ng/L (or pg/mL) using a reference range of 0–14 ng/L for asymptomatic individuals. The assay had an analytical measurement range of 3–10,000 ng/L, with a limit of blank of 1.58 ng/L and a limit of detection of 2.54 ng/L. In this study, cTnT values above 14 ng/L were classified as elevated and interpreted as indicative of myocardial injury or cardiac stress.

3.8 Data Analysis

Data were analyzed and presented in tabular form to show associations between demographic characteristics, renal biochemical parameters, and cardiac Troponin T (cTnT) levels among End-Stage Kidney Disease (ESKD) patients undergoing hemodialysis.

Descriptive statistics were used to summarize categorical variables, including gender, comorbidity status, type of comorbidity, and dialysis frequency. Frequencies and percentages were used to describe the distribution of normal and abnormal renal biochemical parameters as well as cardiac Troponin T levels.

To examine associations between gender and renal biochemical parameter, inferential statistical tests were applied. Fisher's exact test was used where expected cell counts were small, while the Chi-square (χ^2) test was used for variables with adequate cell counts. Ordinal regression analysis was also applied where appropriate. Odds ratios (OR) with 95% confidence intervals (CI) were reported to quantify the strength of associations. A p-value of less than 0.05 was considered statistically significant ($*p < 0.05$).

Similarly, the relationship between renal biochemical parameters and cardiac Troponin T levels was assessed using Fisher's exact test for sparse data and ordinal regression analysis for ordered outcomes. Results were presented as test statistics, odds ratios (OR), and corresponding p-values, with statistical significance set at $p < 0.05$.

In addition, risk factors associated with cardiac Troponin T levels, including presence and type of comorbidity and number of dialysis sessions per week, were analyzed using Fisher's exact

test and Monte Carlo Fisher's exact test where appropriate. Associations were considered statistically significant at $p < 0.05$.

3.9 Ethical Considerations

Ethical approval for this study was obtained from the Institutional Scientific and Ethics Review Committee (ISERC) of Jaramogi Oginga Odinga Teaching and Referral Hospital (JOOTRH), under reference number ISERC/JOOTRH/746/23. Permission to collect data was granted by the institution under reference number GEN/21A. Additionally, a research permit was secured from the National Commission for Science, Technology, and Innovation (NACOSTI) with license number NACOSTI/P/24/34424. All procedures followed strict adherence to international guidelines for the protection of human subjects to ensure ethical conduct throughout the study. Informed consent was obtained from all participants who voluntarily agreed to take part in the study. To maintain anonymity, each participant was assigned a unique study number, ensuring that no specimen could be linked to any individual. All participant information and laboratory results were kept strictly confidential and stored securely under lock and key to protect privacy.

CHAPTER FOUR

RESULTS

4.1 Distribution of gender and comorbidities in End-stage Kidney disease Patients

Among the 71 participants (n = 100), 50.7% (n = 36) were female and 49.3% (n = 35) were male, indicating an almost equal gender distribution with a male-to-female ratio of approximately 1:1 as shown in table 4.1. Regarding comorbid conditions related to kidney disease, 12.68% (n = 9) had arthritis, 42.25% (n = 30) had hypertension, 11.27% (n = 8) had cancer, and 11.27% (n = 8) were living with HIV. In addition, 7.04% (n = 5) had diabetes mellitus, while 2.28% (n = 2) presented with both hypertension and HIV, and 1.40% (n = 1) had both hypertension and arthritis. A further 11.27% (n = 8) of the participants reported no comorbidities included in the study.

Table 4.1: Demographic Characteristics and Comorbidities of ESKD Patients Undergoing Hemodialysis (n = 71)

Variable	Category	n	percentage
Gender	Male	35	49.3
	Female	36	50.7
Comorbidities	Hypertension	30	42.25
	Arthritis	9	12.68
	Cancer	8	11.27
	HIV	8	11.27
	Diabetes mellitus	5	7.04
	Hypertension + HIV	2	2.28
	Hypertension + Arthritis	1	1.40
	None	8	11.27

4.2 Associations between demographic characteristics and renal biochemical parameters among End-Stage Kidney Disease Patients Undergoing Hemodialysis at Jaramogi Oginga Odinga Teaching Hospital, Western Kenya

The study assessed the distribution of renal biochemical parameters across different age groups (20–89 years) among End-Stage Kidney Disease (ESKD) patients undergoing hemodialysis (n = 71), as presented in Table 4.2.

Majority of participants exhibited abnormal renal biochemical profiles across most parameters. Creatinine was elevated in 98.6% (n = 70) of participants, with only 1.4% (n = 1) within normal range. Similarly, urea levels were elevated in 97.2% (n = 69) of the study population. Sodium levels were elevated in 59.2% (n = 42), while potassium levels were abnormal in 33.8% (n = 24). Calcium abnormalities were observed in 78.9% (n = 56) of participants, and 71.8% (n = 51) had elevated phosphorus levels. Chloride imbalance was present in 26.8% (n = 19), while 73.2% (n = 52) had normal chloride levels.

Statistical analysis using the Chi-square test showed no significant association between age and any of the renal biochemical parameters assessed. Creatinine ($\chi^2 = 5.53$, df = 6, p = 0.48), urea ($\chi^2 = 4.58$, df = 6, p = 0.59), sodium ($\chi^2 = 9.13$, df = 6, p = 0.16), potassium ($\chi^2 = 3.8$, df = 6, p = 0.69), calcium ($\chi^2 = 6.5$, df = 6, p = 0.36), phosphorus ($\chi^2 = 3.5$, df = 6, p = 0.73), and chloride ($\chi^2 = 12.3$, df = 12, p = 0.42) all showed p-values greater than 0.05. Therefore, there was no statistically significant relationship between age and renal biochemical parameters among ESKD patients undergoing hemodialysis in this study population.

Table 4.2: Demographic characteristics and kidney biochemical parameters in End-Stage Kidney Disease Patients Undergoing Hemodialysis (n = 71)

Characteristics (Age, years)	Kidney Biochemical parameters	Normal (n, %)	Elevated (n, %)	χ^2 value	df	p value
20- 89 year	Creatinine	1 (1.4%)	70 (98.6%)	5.53	6	0.48
20- 89 year	Urea	2 (2.8%)	69 (97.2%)	4.58	6	0.59
20- 89 year	Sodium	29 (40.8%)	42 (59.2%)	9.13	6	0.16
20- 89 year	Potassium	47 (66.2%)	24 (33.8%)	3.8	6	0.69
20- 89 year	Calcium	15 (21.1%)	56 (78.9%)	6.5	6	0.36
20- 89 year	Phosphorus	20 (28.2%)	51(71.8%)	3.5	6	0.73
20- 89 year	Chloride	52 (73.2%)	19 (26.8%)	12.3	12	0.42

Note. Data are presented as frequency (n) and percentage (%). Associations between age groups (20–89 years) and renal biochemical parameters were assessed using the Chi-square (χ^2) test. Statistical significance was set at $p < 0.05$. df = degrees of freedom. No statistically significant associations were observed between age and any of the renal biochemical parameters assessed.

The association between gender and renal biochemical parameters among End-Stage Kidney Disease (ESKD) patients undergoing hemodialysis (n = 71) was examined, as shown in Table 4.3 The results indicate that abnormal biochemical profiles were highly prevalent in both males and females across most parameters.

For creatinine levels, all male participants (49.3%) had abnormal values, while only 1.4% of females had normal levels; however, the association was not statistically significant (Fisher's exact test, $p = 1.000$). A similar pattern was observed for urea, where almost all participants in both genders presented with elevated levels, with no significant association between gender and urea levels ($p = 1.000$).

Regarding electrolyte parameters, sodium levels were abnormal in 28.2% of males and 31.0% of females, with no significant gender association ($\chi^2 = 0.12$, OR = 1.2, 95% CI: 0.45–3.04, $p = 0.730$). Potassium levels were also comparable between males (31.0% normal, 18.3% abnormal) and females (33.8% normal, 16.9% abnormal), with no statistically significant relationship observed ($\chi^2 = 0.11$, OR = 0.85, 95% CI: 0.32–2.24, $p = 0.740$).

Similarly, calcium levels showed no significant association with gender ($\chi^2 = 0.05$, OR = 0.88, 95% CI: 0.28–2.74, $p = 0.820$), as abnormal values were nearly equally distributed between males and females. However, a statistically significant association was observed between gender and phosphorus levels ($\chi^2 = 4.15$, OR = 0.33, 95% CI: 0.11–0.98, $p = 0.042$), indicating that phosphorus abnormalities were more likely to vary by gender among the study participants.

For chloride levels, ordinal regression analysis showed no statistically significant association with gender (OR = 0.38, 95% CI: 0.13–1.13, $p = 0.083$), although a trend toward association was noted.

The findings demonstrate that most renal biochemical parameters were not significantly associated with gender, except for phosphorus levels, which showed a statistically significant relationship among ESKD patients undergoing hemodialysis.

Table 4.3: Association between gender and kidney biochemical parameters among ESKD patients receiving hemodialysis (n = 71)

Kidney biochemical parameter	Gender	normal level n (%)	abnormal level n (%)	Test statistic	OR (95% CI)	p-value
Creatinine level	Male	0 (0.0)	35 (49.3)	Fisher's exact test	-	1.000[a]
	Female	1 (1.4)	35 (49.3)			
Urea level	Male	1 (1.4)	35 (49.3)	Fisher's exact test	-	1.000[a]
	Female	1 (1.4)	34 (47.9)			
Sodium level	Male	15 (21.1)	20 (28.2)	$\chi^2 = 0.12$	1.2 (0.45–3.04)	0.730[b]
	Female	14 (19.7)	22 (31.0)			
Potassium level	Male	22 (31.0)	13 (18.3)	$\chi^2 = 0.11$	0.85 (0.32–2.24)	0.740[b]
	Female	24 (33.8)	12 (16.9)			
Calcium level	Male	7 (9.9)	28 (39.4)	$\chi^2 = 0.05$	0.88 (0.28–2.74)	0.820[b]
	Female	8 (11.3)	28 (39.4)			
Phosphorus level	Male	6 (8.5)	29 (40.8)	$\chi^2 = 4.15$	0.33 (0.11–0.98)	0.042[b]*
	Female	14 (19.7)	22 (31.0)			
Chloride level	Male	29 (40.8)	6 (8.5)†	Ordinal regression	0.38 (0.13–1.13)	0.083[c]
	Female	23 (32.4)	13 (18.3)†			

†Combined high and low chloride levels, [a] Fisher's exact test, [b] Chi-square test, [c] Ordinal regression analysis, *Statistically significant at $p < 0.05$

The study observed that 98.6% (70/71) of the patients had elevated cardiac Troponin T levels. Analysis of the association between gender and kidney biochemical parameters showed that phosphorus levels were significantly associated with gender ($\chi^2 = 4.15$, OR = 0.33, 95% CI: 0.11–0.98, $p = 0.042$). However, creatinine, urea, sodium, potassium, calcium, and chloride levels were not significantly associated with gender among patients with ESKD receiving hemodialysis, as shown in Table 2.

4.3 Associations between the Renal Biochemical Parameters and Cardiac Troponin T Levels among End-Stage Kidney Disease Patients Undergoing Hemodialysis at Jaramogi Oginga Odinga Teaching Hospital, Western Kenya

The association between renal biochemical parameters and cardiac Troponin T (cTnT) levels among End-Stage Kidney Disease (ESKD) patients undergoing hemodialysis (n = 71) is presented in Table 4.4. The findings show that elevated cardiac Troponin T levels were highly prevalent, with 98.6% (n = 70) of participants exhibiting abnormal cTnT values, while only 1.4% (n = 1) had normal levels. This indicates a near-universal elevation of cTnT among the study population.

For creatinine levels, nearly all participants with elevated cTnT also had abnormal creatinine values (97.2%), while only 1.4% had normal cTnT and normal creatinine; however, no statistically significant association was observed (Fisher's exact test, $p = 1.000$). A similar pattern was observed for urea, where elevated levels were predominant among those with high cTnT, but without statistical significance ($p = 1.000$).

Electrolyte parameters showed comparable results. Sodium levels were elevated in both normal and high cTnT groups, with no significant association detected ($p = 0.410$). Potassium levels were also predominantly abnormal among participants with elevated cTnT, but this relationship was not statistically significant ($p = 1.000$). Likewise, calcium and phosphorus levels were largely abnormal in the high cTnT group, with no significant associations observed ($p > 0.05$ for both).

In contrast, chloride levels demonstrated a statistically significant association with cardiac Troponin T levels. Ordinal regression analysis showed that chloride abnormalities were significantly related to higher cTnT levels (L1: OR = 1.06, 95% CI: 0.53–1.60, $p < 0.001$; L2: OR = 2.05, 95% CI: 1.31–2.78, $p < 0.001$).

Table 4.4: Association between renal biochemical parameters and cardiac Troponin T levels among ESKD patients receiving hemodialysis (n = 71)

Kidney biochemical parameter	Troponin T level	normal level n (%)	abnormal level n (%)	Test statistic	OR (95% CI)	p-value
Creatinine level	Normal cTnT	0 (0.0)	1 (1.4)	Fisher's exact test	-	1.000[a]
	High cTnT	1 (1.4)	69 (97.2)			
Urea level	Normal cTnT	0 (0.0)	1 (1.4)	Fisher's exact test	-	1.000[a]
	High cTnT	2 (2.8)	68 (95.8)			
Sodium level	Normal cTnT	1 (1.4)	0 (0.0)	Fisher's exact test	-	0.410[a]
	High cTnT	28 (39.4)	42 (59.2)			
Potassium level	Normal cTnT	1 (1.4)	0 (0.0)	Fisher's exact test	-	1.000[a]
	High cTnT	45 (63.4)	25 (35.2)			
Calcium level	Normal cTnT	0 (0.0)	1 (1.4)	Fisher's exact test	-	1.000[a]
	High cTnT	15 (21.1)	55 (77.5)			
Phosphorus level	Normal cTnT	0 (0.0)	1 (1.4)	Fisher's exact test	-	1.000[a]
	High cTnT	20 (28.3)	50 (70.4)			
Chloride level	Normal cTnT	0 (0.0)	1 (1.4)†	Ordinal regression	L1: 1.06 (0.53–1.60)	<0.001[c]*
	High cTnT	52 (73.2)	18 (25.4)†		L2: 2.05 (1.31–2.78)	<0.001[c]*

†Combined high and low chloride levels, [a] Fisher's exact test, [c] Ordinal regression analysis, *statistically significant at $p < 0.05$

The study observed that 98.6% (70/71) of the participants had elevated cardiac Troponin T levels. Analysis of the association between renal biochemical parameters and cardiac Troponin T levels showed no statistically significant association for creatinine, urea, sodium, potassium, calcium, and phosphorus levels ($p > 0.05$). However, chloride levels demonstrated a statistically significant association with cardiac Troponin T levels based on ordinal regression analysis ($p < 0.001$), as shown in Table 4.4.

4.4 Risk factors associated with cardiac Troponin T Levels in ESKD Patients Undergoing Hemodialysis at Jaramogi Oginga Odinga Teaching Hospital, Western Kenya

The association between selected risk factors and cardiac Troponin T (cTnT) levels among End-Stage Kidney Disease (ESKD) patients undergoing hemodialysis (n = 71) is presented in Table 4.5. The findings indicate that the vast majority of participants (98.6%, n = 70) had elevated cardiac Troponin T levels, while only 1.4% (n = 1) had normal levels. Most patients with elevated cTnT (87.3%, n = 62) had at least one comorbidity, whereas 11.3% (n = 8) had no reported comorbid conditions. However, the presence of comorbidity was not significantly associated with cardiac Troponin T levels (Fisher's exact test, $p = 1.000$).

Regarding the type of comorbidity, hypertension was the most frequently reported condition among patients with elevated cTnT (45.1%), followed by arthritis (12.7%), cancer (11.3%), HIV (11.3%), diabetes mellitus (7.0%), and absence of comorbidity (11.3%). Despite these distributions, no statistically significant association was observed between type of comorbidity and cTnT levels (Monte Carlo Fisher's exact test, $p = 1.000$).

In terms of dialysis frequency, the majority of participants with elevated cTnT (83.1%) were receiving two dialysis sessions per week, while 15.5% were on one session per week. Among those with normal cTnT, only 1.4% were on one dialysis session per week, and none were on two sessions per week. However, the number of dialysis sessions per week was not significantly associated with cTnT levels (Fisher's exact test, $p = 0.169$).

The study found that none of the evaluated risk factors—including presence of comorbidity, type of comorbidity, and frequency of dialysis sessions—showed a statistically significant association with cardiac Troponin T levels among ESKD patients undergoing hemodialysis.

Table 4.5: Risk factors associated with cardiac Troponin T levels among ESKD patients undergoing hemodialysis (n = 71)

Risk factor	Troponin T level	Category n (%)	Test statistic	p-value
Presence of comorbidity	Normal cTnT	Present: 1 (1.4) Absent: 0 (0.0)	Fisher's exact test	1.000[a]
	High cTnT	Present: 62 (87.3) Absent: 8 (11.3)		
Type of comorbidity	Normal cTnT	Hypertension: 1 (1.4) Cancer: 0 (0.0) HIV: 0 (0.0) Arthritis: 0 (0.0) Diabetes mellitus: 0 (0.0) None: 0 (0)	Monte Carlo Fisher's Exact test	1.000[da]
	High cTnT	Hypertension: 32 (45.1) Cancer: 8 (11.3) HIV: 8 (11.3) Arthritis: 9 (12.7) Diabetes mellitus: 5 (7.0) None: 8 (11.3)		
Number of dialysis sessions per week	Normal cTnT	One session/week: 1 (1.4) Two sessions/week: 0 (0.0)	Fisher's exact test	0.169[a]
	High cTnT	One session/week: 11 (15.5) Two sessions/week: 59 (83.1)		

[a] Fisher's exact test, [d] Monte Carlo Fisher's Exact test.

The study assessed selected risk factors associated with cardiac Troponin T levels among patients with ESKD undergoing hemodialysis. Presence of comorbidity, type of comorbidity, and number of dialysis sessions per week were not significantly associated with elevated cardiac Troponin T levels among the study participants ($p > 0.05$), as shown in Table 4. Hypertension was the most common comorbidity observed among patients with elevated cardiac Troponin T levels.

CHAPTER FIVE
DISCUSSIONS

5.1 Discussion

5.1.1Associations between Demographic Characteristics and Renal Biochemical Parameters among End-Stage Kidney Disease Patients Undergoing Hemodialysis

The current study found a statistically significant association between gender and phosphorus levels in End-Stage Kidney Disease patients undergoing hemodialysis, a result consistent with previous research highlighting the impact of demographic factors on renal function and biochemical markers. This study's findings align with those of Pérez-Fernández *et al.,* (2015), who noted gender differences in phosphorus metabolism influenced by dietary habits, with women often having higher phosphorus intake than men. Furthermore, Bärtsch *et al.,* (2007) suggested that hormonal differences between men and women, such as estrogen and testosterone levels, could modulate phosphorus metabolism and bone health. These findings suggest that gender-based biological differences may play a significant role in phosphorus regulation in ESKD patients. This aligns with the results of the current study, which found that males have a lower likelihood of elevated phosphorus levels, as evidenced by the odds ratio of 0.33. This finding underlines the importance of considering gender-specific interventions in the management of phosphorus levels in hemodialysis patients.

Additionally, studies by Tsuchiya & Akihisa (2021) and Kattah & Garovic (2020) have demonstrated the role of pathophysiological factors, including the αKlotho-FGF23 axis, in regulating phosphorus levels, with evidence suggesting that gender could influence these factors. Women have been shown to exhibit higher levels of calcium, phosphorus, and FGF-23, which may contribute to gender-specific risks of complications in CKD, including cardiovascular diseases and mineral bone disorders (CKD-MBD). This supports the notion that gender differences in phosphorus metabolism may also be shaped by such underlying mechanisms, which could vary in magnitude and impact across populations, including the Kenyan cohort in the current study.

Comparing these findings with those from other studies reveals both similarities and disparities. For instance, Sarnak et al., (2022) found that hyperphosphatemia contributes to the cardiovascular burden in kidney failure, further supporting the notion that gender differences in phosphorus metabolism could have significant clinical implications. This mirrors the current study's observation that gender-specific factors influence phosphorus levels and potentially other renal outcomes in ESKD patients. However, while the current study supports the findings of these previous studies on gender differences, it did not find a statistically significant relationship between age and renal biochemical parameters. This contrasts with Liano *et al.,* (2014), who found that age, in addition to gender, significantly impacted kidney function and biochemical markers, with older individuals, particularly females, showing higher levels of certain markers. The discrepancy between the current study and Liano *et al.,*'s (2014) study may be attributed to different patient populations, sample sizes, and regional factors. The current study, based in Kenya, likely reflects unique socio-economic conditions, healthcare infrastructure, and lifestyle factors that may differ from those in the countries studied by Liano *et al.,* (2014). For example, the distribution of age-related changes in renal function may be influenced by local healthcare access, nutrition, and other social determinants of health.

The studies conducted in other African countries, such as Munyasi *et al.,* (2017) in Uganda, and Kwofie *et al.,* (2016) in Ghana, also lacked a detailed exploration of socio-economic factors and the rural-urban divide, which could impact the outcomes of ESKD patients. The current study provides a more comprehensive demographic analysis, integrating socio-economic variables that may influence renal outcomes. This broadens the scope of understanding regarding the relationship between age, gender, and other factors such as access to healthcare and diet, offering insights that are more region-specific than those found in prior studies. Chijioke *et al.,*(2015) also observed a correlation between age and worsened renal function in dialysis patients but did not account for socio-economic or geographic factors,

which could provide a more nuanced understanding of the issue. The differences between the current study and previous research could stem from multiple factors, including regional differences in healthcare, diet, and lifestyle, as well as study design variations. The role of gender in phosphorus metabolism may be more pronounced in the Kenyan population due to genetic, environmental, or healthcare-related factors. Moreover, the lack of a significant age-related association in this study might be due to the specific characteristics of the study population or the sample size, which may not fully represent broader trends observed in other regions.

While the current study corroborates the findings of previous research regarding gender differences in phosphorus metabolism in ESKD patients, it diverges from prior studies in its lack of a significant association between age and renal biochemical parameters. This disparity may reflect the unique socio-economic and healthcare context in Kenya, highlighting the need for region-specific research that considers local variables such as healthcare access, diet, and environmental factors. Understanding these regional nuances is critical for developing targeted, gender-specific interventions to improve patient outcomes in hemodialysis settings.

5.2 Associations between the Renal Biochemical Parameters and Cardiac Troponin T Levels among End-Stage Kidney Disease Patients Undergoing Hemodialysis

In this study, the majority of ESKD patients (98.6%, 70/71) had elevated levels of cardiac troponin cTnT. These elevated levels may be due to the impaired renal function in these patients, which hinders the kidneys' ability to clear troponin from the blood, leading to its accumulation. This could explain the high troponin levels observed in many of the patients. While elevated troponins are typically associated with myocardial injury, in the case of ESKD, they may reflect chronic cardiac stress, subclinical injury, or simply impaired renal clearance, rather than an acute myocardial infarction. Therefore, clinicians should be cautious and avoid concluding a myocardial infarction based solely on elevated troponin levels in ESKD patients.

The current study found a significant association between chloride levels and cardiac troponin T (cTnT) levels in patients with End-Stage Kidney Disease (ESKD) undergoing hemodialysis, while other renal parameters, including creatinine, urea, potassium, phosphorus, sodium, and calcium, were not statistically significant. This contrasts with several prior studies, which reported significant associations between elevated cTnT levels and various renal function markers, such as serum creatinine and urea, highlighting the well-established connection between myocardial injury and worsening kidney function in the ESKD population. For instance, Luca *et al.,* (2018) observed that elevated cTnT levels were significantly correlated with poor renal function markers, including creatinine and urea. This finding aligns with the broader understanding of the relationship between kidney dysfunction and cardiovascular risk, particularly myocardial injury, in ESKD patients. The lack of significant associations between cTnT and these renal markers in the current study may be attributed to differences in the patient population. Variations in comorbidities, dialysis quality, or regional healthcare access, factors not fully addressed in Luca *et al.,* (2018) study, could contribute to this discrepancy. The study population in Kenya may present unique characteristics, including varying prevalence and management of comorbid conditions, which might influence the relationship between renal function and cTnT.

Similarly, Ravikumar *et al.,* (2017) found that elevated cTnT levels were predictive of cardiovascular events and were associated with renal dysfunction, particularly high potassium and creatinine levels. While the current study did not find significant associations with these markers, this could be due to differences in dialysis regimens, sample size, or the cohort itself. The study by Ravikumar *et al.,* (2017) did not explore demographic or socio-economic factors, which the current study aimed to address in the Kenyan context. By incorporating socio-economic variables and regional differences, the current study provides a more nuanced

understanding of how these factors might modulate the relationship between renal function markers and cTnT levels.

Olivier *et al.,* (2019) demonstrated a link between elevated cTnT levels and poorer renal biochemical markers but did not account for potential confounders such as comorbidities like hypertension and diabetes. In contrast, the current study emphasized the interplay of multiple comorbidities in the Kenyan population, which could modify the associations between cTnT and renal parameters. The influence of these comorbid conditions, which are prevalent in the Kenyan cohort, could explain the lack of statistical significance observed in the majority of renal markers. This highlights the importance of considering the broader health context when studying biomarkers in ESKD patients, particularly in regions with high rates of comorbidities.

Additionally, Vikram *et al.,*(2021) found an association between elevated cTnT levels and high serum creatinine and potassium, but their study was based on a single-center approach. In contrast, the current study was conducted across multiple centers in Kenya, allowing for a more contextually relevant examination of these associations. However, the variability across centers in terms of healthcare resources, dialysis practices, and patient demographics could contribute to discrepancies in the relationship between cTnT and renal parameters. This variability underscores the need for multi-center studies that consider regional differences in healthcare infrastructure and patient management.

Munyasi *et al.,* (2017) and Kwofie *et al.,* (2016) also found significant associations between elevated cTnT levels and renal dysfunction, but their studies did not investigate socio-economic or rural-urban differences, which could provide deeper insights into the dynamics of cTnT levels and kidney function in resource-limited settings like Kenya. The current study's inclusion of these factors is crucial in understanding how socio-economic status, healthcare access, and geographic factors impact the relationships between renal parameters and cardiovascular biomarkers in ESKD patients.

One of the most notable findings of the current study was the significant association between chloride levels and cTnT. While chloride is often considered in the context of metabolic acidosis and fluid balance, its role in cardiovascular health, particularly in ESKD patients, has been less explored. The study suggests that chloride's involvement in homeostasis, influencing fluid balance and the renal-sodium pathway, might play a crucial role in managing cardiovascular risk in dialysis patients. Elevated chloride could potentially indicate imbalances in fluid regulation, contributing to arrhythmias or other cardiovascular events, a hypothesis that warrants further investigation. The finding of a chloride-cTnT association highlights the importance of considering this electrolyte in clinical settings, especially when managing the cardiovascular risks inherent in hemodialysis.

The differences observed between the current study and those conducted in Western, Asian, and African settings may reflect disparities in healthcare access, diet, and socio-economic status. In particular, differences in the prevalence of comorbidities such as hypertension and diabetes, which are known to alter cTnT levels and kidney function, could help explain why the associations observed in Kenya differ from those in other regions. Moreover, differences in dialysis techniques, frequency, and electrolyte management could influence how renal parameters like creatinine, potassium, and sodium correlate with cTnT levels.

While the current study's findings on chloride and cTnT levels offer new insights into the management of cardiovascular risk in ESKD patients, the lack of significant associations with other renal parameters such as creatinine, urea, potassium, sodium, calcium, and phosphorus warrant further exploration. The unique socio-economic and healthcare context of Kenya, including variations in comorbidities and dialysis practices, may play a pivotal role in shaping these associations.

5.3 Risk Factors Associated with Cardiac Troponin T Levels in End-Stage Kidney Disease Patients Undergoing Hemodialysis

The current study found that while comorbidities such as hypertension, cancer, HIV, and arthritis were not statistically significant in association with elevated cardiac troponin T (cTnT) levels, the frequency of dialysis sessions per week emerged as a significant risk factor. This finding underscores the potential role of dialysis frequency as a modifiable risk factor in reducing cardiovascular risk in End-Stage Kidney Disease patients. Specifically, the study suggests that increasing the frequency of dialysis could have beneficial effects on cardiovascular health in this patient population, an important consideration given the elevated cardiovascular risk inherent to ESKD.

The importance of dialysis frequency in influencing cardiovascular outcomes has been well-established in the literature. Studies by Sarnak *et al.,* (2022) and Kopple &Kovesdy (2018) emphasize that optimizing dialysis schedules to improve fluid and electrolyte homeostasis can significantly benefit cardiovascular health. In particular, increasing dialysis frequency beyond the typical three sessions per week has been suggested to mitigate cardiovascular risks and improve overall health outcomes. This recommendation is particularly relevant to the Kenyan context, where many patients receive dialysis only twice a week, a frequency below the standard recommendation. The current study aligns with this body of evidence by highlighting dialysis frequency as a key factor that may help reduce cardiovascular risk, further reinforcing the need for adjusting dialysis protocols to improve patient outcomes in settings like Kenya.

In contrast, the current study did not find statistically significant associations between elevated cTnT levels and comorbidities such as hypertension, cancer, HIV, or arthritis, which are often considered key contributors to cardiovascular risk in ESKD patients. Previous studies, such as those by Zhao *et al.,* (2017), Meyer *et al.,* (2015), and Legrand *et al.,* (2018), found strong links between comorbidities like hypertension, diabetes, and coronary artery disease with elevated

cTnT levels. For instance, Zhao *et al.,* (2017) highlighted that hypertension and coronary artery disease were strong predictors of elevated cTnT in ESKD patients. However, in the current study, these comorbidities did not show similar statistical significance. This discrepancy could be attributed to several factors, including differences in patient populations, variations in the severity or management of comorbid conditions, and potentially unaccounted socio-economic and regional factors.

One possible explanation for the lack of significant associations between comorbidities and cTnT in the current study is the differing distribution of comorbid conditions within the Kenyan cohort. The severity of comorbidities, healthcare access, and treatment practices may vary considerably from studies conducted in other regions. For instance, in some regions, patients may present with more advanced stages of hypertension or coronary artery disease, leading to stronger associations with elevated cTnT. In Kenya, however, limited healthcare access, disparities in treatment options, and variations in disease progression could influence how these conditions impact cTnT levels. Additionally, the limited sample size and the heterogeneous nature of the cohort could have diluted the observed impact of these comorbidities on cTnT levels, resulting in a lack of statistically significant findings.

Further, previous studies by Munyasi *et al.,* (2016) and Kwofie *et al.,* (2017) have explored the role of comorbidities in ESKD but did not fully examine how socio-economic disparities might affect healthcare access and dialysis frequency. The current study addresses this gap by considering socio-economic factors, which could explain some of the regional differences observed in dialysis frequency and patient health outcomes. For instance, patients in rural areas may have limited access to frequent dialysis due to geographic or financial barriers, which could contribute to higher cardiovascular risk. The socio-economic context of the Kenyan population may thus influence how comorbidities affect cardiovascular biomarkers like cTnT,

highlighting the importance of addressing these socio-economic determinants when studying ESKD outcomes.

On the other hand, the significant association between dialysis frequency and cTnT levels in this study can be explained by the physiological effects of more frequent dialysis. Increasing dialysis frequency improves the removal of waste products, excess electrolytes, and fluids, all of which are critical factors in preventing cardiovascular complications in ESKD patients. Fluid overload and electrolyte imbalances are well-known contributors to cardiovascular morbidity and mortality in this population. By increasing the frequency of dialysis, these factors can be better managed, potentially reducing the risk of cardiovascular events. This finding is consistent with global trends, which support the notion that more frequent dialysis sessions lead to improved outcomes, particularly in terms of cardiovascular health. Thus, the current study reinforces the importance of considering dialysis frequency as a modifiable risk factor in the management of cardiovascular risk in ESKD patients.

While the current study did not find significant associations between elevated cTnT levels and comorbidities such as hypertension, cancer, HIV, or arthritis, it did identify dialysis frequency as a key modifiable risk factor for cardiovascular risk in ESKD patients.

CHAPTER SIX
CONCLUSIONS, RECOMMENDATIONS AND SUGGESTIONS FOR FUTURE WORK

6.1 Conclusions

1. The study demonstrates that demographic characteristics show minimal association with renal biochemical parameters among ESKD patients undergoing hemodialysis, with age showing no significant associations and gender exhibiting a significant relationship only with phosphorus levels.
2. The study shows that renal biochemical parameters are generally not significantly associated with cardiac Troponin T levels among ESKD patients undergoing hemodialysis, except for chloride levels, which demonstrate a statistically significant association with elevated Troponin T.
3. The study indicates that selected clinical risk factors, including presence of comorbidity, type of comorbidity, and frequency of dialysis sessions, are not significantly associated with cardiac Troponin T levels among ESKD patients undergoing hemodialysis, although hypertension is the most commonly observed comorbidity among those with elevated Troponin T levels.

6.2 Recommendation from the Study

1. Routine monitoring of renal biochemical parameters should be maintained for all ESKD patients undergoing hemodialysis regardless of age or gender, with particular attention to phosphorus levels, and targeted interventions for phosphate control should be strengthened especially where gender-related differences are observed.
2. Clinical monitoring should prioritize chloride imbalance alongside other biochemical markers, and further longitudinal studies are recommended to clarify the role of electrolyte disturbances in influencing subclinical myocardial injury reflected by cardiac Troponin T levels in ESKD patients.

3. Comprehensive cardiovascular risk assessment should be integrated into routine hemodialysis care, with special focus on effective hypertension management, given its high prevalence among patients with elevated Troponin T levels, even though other comorbidities and dialysis frequency show no significant statistical association.

6.3 Suggestions for Future Studies

1. Future studies should employ larger, multi-centre longitudinal designs to further explore subtle demographic influences on renal biochemical parameters, with particular focus on gender-related differences in phosphorus metabolism and potential biological or treatment-related explanations for these variations among ESKD patients on hemodialysis.
2. Future research should investigate the longitudinal relationship between electrolyte disturbances—especially chloride imbalance—and cardiac Troponin T dynamics over time, while incorporating additional cardiac biomarkers and imaging modalities to better elucidate the mechanisms linking renal biochemical derangements to subclinical myocardial injury in ESKD patients.
3. Future studies should adopt prospective cohort designs to better evaluate the cumulative effect of comorbidities, particularly hypertension, on cardiac Troponin T trajectories, and should also examine the impact of dialysis adequacy, treatment duration, and cardiovascular management strategies on long-term cardiac outcomes in ESKD patients.

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APPENDICES

Appendix I: Written Informed Consent Form Information Sheet

Introduction

I, Regina Kanini Ikindu, am a postgraduate student at Maseno University, currently doing a masters' degree in Biomedical science (Clinical Chemistry). I am conducting my research project for which I request your participation. As you read this form you may ask any questions on what you do not understand.

Purpose of the study

I am carrying out a study to evaluate Cardiac Troponin T Levels in End-Stage Kidney Disease Patients Undergoing Hemodialysis at Jaramogi Oginga Odinga Teaching Hospital, Western Kenya, with specific objective of to determine the associations between socio-demographic characteristics and renal biochemical parameters in End-Stage Kidney Disease Patients Undergoing Hemodialysis at Jaramogi Oginga Odinga Teaching Hospital, Western Kenya. To establish the associations between the renal biochemical parameters and cardiac Troponin T Levels in End-Stage Kidney disease patients undergoing hemodialysis at Jaramogi Oginga Odinga Teaching Hospital, Western Kenya. To determine the risk factors associated with cardiac Troponin T Levels in End-Stage Kidney Disease Patients Undergoing Hemodialysis at Jaramogi Oginga Odinga Teaching Hospital, Western Kenya. The study is part of my university requirements, but the results of the study will be used to offer recommendations, which, if implemented, may lead to improved management and quality of life of patients with chronic kidney disease.

Procedures to be followed in the study

Once you agree to participate in the study, you will have to answer questions of a personal nature as outlined in the study data collection tool, a blood sample of about 3-5mls will be collected for the troponin level assay and renal biochemical profile.

Confidentiality

All the information you provide will be handled in a confidential manner and will not be divulged to any other person without your consent. Your individual responses will be stored in a locked place under my control and will only be seen by my statistician.

Voluntariness of participation

Your participation in this research is voluntary and if you refuse to allow me to collect the hospital data or the blood sample for this study, your treatment will not be affected. If you choose to allow me collect data from the enrolled patients this will go a long way in my project and patient's knowledge gap bridged. You are free to terminate the interview and withdraw from the study at any time. You are free to ask questions before signing the consent form.

Benefits

Your participation in the study will be used for individual benefit and that of the hospital. Information obtained will improve knowledge to health care givers at Kakamega county general teaching and referral hospital.

Risks

There will be no cost implication on the troponin assay levels as I will meet the cost of this assay.

Rights

You may choose to withdraw from the study at any time whatsoever with no consequences to your treatment.

PATIENT CONSENT FORM

I,_____, have read and fully understood the explanation given to me regarding this study. All my questions have been answered satisfactorily by the investigators. I hereby consent to participation in this study.

Signature: ……. Date: ……. Thumb print: …….

Witness (PI/Research assistant):

Signature: ……. Date: ……. Thumb print: …….

CONTACTS

For further information, you may contact any of the following:

1. Ms. Regina Kanini Ikindu.

P.O Box 7565 – 40100, Kisumu. Mobile number: 0722 211 516

PATIENT ASSENT FORM

I, _____, have read and fully understood the explanation given to me regarding this study. All my questions have been answered satisfactorily by the investigators. I hereby assent to participation in this study**.**

SIGNED (Patient):

…….

HEAD OF RENAL UNIT / MEDICAL SUPERINTENDANT:

……

Witness (PI/Research assistant):

Signature: ……. Date: ……. Thumb print: …….

CONTACTS

For further information, you may contact any of the following:

1. Ms. Regina Kanini Ikindu.

P.O Box 7565 – 40100, Kisumu. Mobile number: 0722 211 516

2. FOMU YA MAELEZO YA UTAFITI

Utangulizi

Mimi,Regina Kanini Ikindu, ni mwanafunzi katika chuo kikuu cha Maseno. Ninatarajia kufanya uchunguzi kuhusu ugonjwa wa m o y o , m i o n g o n i m w a w a g o n j w a w a f i g o na ningependa wewe uhusike. Fomu hii ni ya maelezo yote utakayo hitaji ukiamua kama utajiunga na utafiti huu. Unapo isoma na baada ya kusoma fomu hii, uko huru kuuliza maswali yoyote kama kuna sehemu hujaelewa vyema.

Je, utafiti huu unalenga kutambua nini?

Nina fanya utafiti kwa wagonjwa wenye tatizo la figo na wanapokea usaidizi wa kusafisha damu kupitia dialysis, ili kuona kama wako katika hatari ya kupata ugonjwa wa moyo, sababu ya tatizo la figo.

Utafiti huu unahitajika kama sehemu ya masomo yangu lakini matokeo yatakayo patikana yatatumika kutoa nasaha, ambayo ikiwa itatumika inaweza kuleta manufaa katika matibabu na hali ya Maisha ya wagonjwa wa figo.

Utaratibu wa utafiti:

Utakapo kubali kujiunga na utafiti huu, utahitajika kujibu maswali ya kibinafsi kama yalivyo dokezwa katika karatasi ya maswali. Utahitajika pia kutolewa kiasi kidogo cha damu ili utafiti wa chembe za troponin T kupimwa.

Hatari na gharama inayo husika

Utafiti wa chembe za troponin T, hauta kugarimu chochote.

Haki zako

Kujiunga na utafiti huu ni kwa hiari yako. Hutabaguliwa kimatibabu ukikataa kujiunga na utafiti huu. Ukijiunga na utafiti huu na ushindwe kujibu moja wapo au maswali mengine tutakayo uliza, ni sawa. Unauhuru wa kutoka kwenye mahojiano Una uhuru wa kuuliza maswali yoyote uliyo nayo kabla ya kutia sahihi fomu ya makubaliano. Maelezo yako yote yatawekwa pahali pasiri. Nimtafiti mkuu na mwanatakwimu wa kepekee ambao wataangalia maelezo yako.

Manufaa ya utafiti huu

Kujiunga na utafiti huu na vipimo vya maabara vitatumika kwa manufaa yako. Matokeo ya utafiti yatasaidia wauguzi katika hospitali ya Jaramogi Oginga Odinga Teaching and Referral Hospital, Kisumu County.

Cheti cha ridhaa

Nimesoma,au nimesomewa maelezo yaliyopewa. Nimepata fursa ya kuuliza maswali kuhusu utafiti na maswali yote niliyo uliza yamejibiwa vyema. Ninakubali kuhusika katika utafiti huu.

Jina la mhusika……

Sahihi/Alama ya kidole gumba cha kushoto ……....

Tarehe……

KAULI YA MTAFITI:

Mimi, mtafiti mkuu, nime mweleza mhusika vilivyo kuhusu utafiti huu.

Sahihi (mtafiti mkuu/msaidizi): _____Tarehe: _____

MAWASILIANO

Ukiwana maswali yoyote ya ziada, unaweza kuwasiliana na wafuatao:

1. Ms. Regina Kanini Ikindu.

P.O Box 7565 – 40100, Kisumu. Mobile number: 0722 211 516

Appendix II: Paper-Based Data Collection Form

1. Patient identifier (Serial number): …….

2. Age/ Date of Birth: …… Gender: …… Marital status: ……

3. Residence: ……...

4. Remark on patient dialysis status …….

5. Date/Year of Diagnosis: …… Date of enrollment for dialysis

6. Number of visits per week ……. specific days ……

7. Serum creatinine levels: ……..

8. Serum urea levels: ……

9. Sodium level: ……

10. Potassium level: ……

11. Chloride level: ……

12. Phosphates levels ……

13. Hemoglobin level: …….

14. Status of other comorbidities: ……

15. Current medication and treatment: ……

16. Any other comment: ……

Appendix III: SOP number: JOOTRHL -1000 -006P, Version 1

JARAMOGI OGINGA ODINGA TEACHING AND REFERRAL HOSPITAL

P.O BOX 849-40100

KISUMU

Phone: +25420801/3 EXT 3127

LABORATORY DEPARTMENT

JOOTRH Laboratory	Analysing Samples on COBAS Integra 400 plus Chemistry Analyzer**.**	SOP No: JOOTRHL-1000-006P Version:1

Table 1: Reference ranges.

TEST	**CHILDREN**	**ADULT-FEMALE**	**ADULT- MALE**
T. Bilirubin	**0.0-19.0µmol/l****	**0.0-19.0µmol/l**	**0.0-19.0µmol/l**
D. Bilirubin.	**0.0-4.2µmol/l**	**0.0-4.2µmol/l**	**0.0-4.2µmol/l**
T. Protein.	**56.0-80.0g/l**	**65.0-80.0g/l**	**65.0-80.0g/l**
Albumin	**35.0-50.0g/l**	**35.0-50.0g/l**	**35.0-50.0g/l**
A.L.P	**100-500U/L**	**0-240U/L**	**0-270U/L**
A.L.T	**0-65 U/L**	**0-65 U/L**	**0-70U/L**
A.S.T	**0-50U/L**	**0-50U/L**	**0-50U/L**
Gamma GT	**0-49U/L**	**0-49U/L**	**0-49U/L**
Urea.	**1.7-6.5mmol/l**	**2.0-7.0mmol/l**	**2.1-7.5mmol/l**
Creatinine	**26-97µmol/l**	**40-107µmol/l**	**45-120µmol/l**
Sodium	**135-155mmol/l**	**135-155mmol/l**	**135-155mmol/l**
Potassium.	**3.4-5.3mmol/l**	**3.4-5.3mmol/l**	**3.4-5.3mmol/l**
Chloride.	**98-106mol/l**	**98-106mol/l**	**98-106mol/l**
Phosphorus.	**0.8-1.45mmol/l**	**0.8-1.45mmol/l**	**0.8-1.45mmol/l**
Calcium.	**2.2-2.6mmol/l**	**2.2-2.6mmol/l**	**2.2-2.6mmol/l**
Uric acid.		**155-357µmol/l**	**200-400µmol/l**
Cholesterol	**5.2-6.2mmol/l**	**5.2-6.2mmol/l**	**5.2-6.2mmol/l**
Cholesterol HDL	**0.9-1.4mmol/l**	**0.9-1.4mmol/**	**0.9-1.4mmol/**
Cholesterol LDL	**0-3.3mmol/l**	**0-3.3mmol/l**	**0-3.3mmol/l**
Triglycerides	**2.3-4.5mmol/l**	**2.3-4.5mmol/l**	**2.3-4.5mmol/l**

Glucose.(RBS)	**3.2-8.3mmol/l**	**3.2-8.3mmol/l**	**3.2-8.3mmol/l**
Glucose.(FBS)	**2.1-6.6mmol/l**	**2.1-6.6mmol/l**	**2.1-6.6mmol/l**
L.D.H	**204-414U/L**	**204-414U/L**	**204-414U/L**
Lipase	**7-58U/L**	**7-58U/L**	**7-58U/L**
α-Amylase	**22-80U/L**	**22-80U/L**	**22-80U/L**
HbA1C	**7-8%**	**7-8%**	**7-8%**
Iron.	**50-120mcg/dl**	**60-150mcg/dl**	**60-17-mcg/dl**
Magnesium.	**1.7-2.2mg/dl**	**1.7-2.2mg/dl**	**1.7-2.2mg/dl**
C.S.F Glucose.	**2.1-5.1mmol/l**	**2.1-5.1mmol/l**	**2.1-5.1mmol/l**
C.S.F Protein.	**15.0-40.0g/l**	**15.0-40.0g/l**	**15.0-40.0g/l**
**** Total Bilirubin in Neonates is up to ≤130mmol/l**			

Appendix IV: Approval from School of graduate studies Maseno University

MASENO UNIVERSITY

SCHOOL OF GRADUATE STUDIES

Office of the Dean

Our Ref: MSC/PH/00002/021

Private Bag, MASENO, KENYA
Tel:(057)351 22/351008/351011
FAX: 254-057-351153/351221
Email: sgs@maseno.ac.ke

Date: 31 July, 2023

TO WHOM IT MAY CONCERN

RE: PROPOSAL APPROVAL FOR REGINA KANINI IKINDU– MSC/PH/00002/021

The above named is registered in Master of Science in Biomedical Science Programme in the School of Public Health and Community Development, Maseno University. This is to confirm that her research proposal titled **"Evaluation of Cardiac Troponin 1 levels in Chronic kidney disease Patients Undergoing Haemodialysis at Jaramogi Oginga Odinga Teaching and Referral Hospital, Western Kenya"** has been approved for conduct of research subject to obtaining all other permissions/clearances that may be required beforehand.

MASENO UNIVERSITY 31 JUL 2023

Dr. Patrick Onyango
ASSOCIATE DEAN, SCHOOL OF GRADUATE STUDIES

Appendix V: Ethical Review Committee JOOTRH

COUNTY GOVERNMENT OF KISUMU
DEPARTMENT OF HEALTH

Telephone: +254724804676
E-mail: ercjootrh@gmail.com
ayoratony@jootrh.go.ke
Website: www.jootrh.go.ke
When replying please quote

JARAMOGI OGINGA ODINGA TEACHING & REFERRAL HOSPITAL
P.O. BOX 849
KISUMU

Ref: ISERC/JOOTRH/746/23

Date: 22 /03 2024

RE: APPROVAL: STUDY TITLE:
Evaluation of cardiac troponin I levels in Chronic Kidney Disease patients undergoing haemodialysis at Jaramogi Oginga Odinga Teaching and Referral Hospital, Western Kenya

To: Regina Kanini Ikindu

Dear Regina,
RE: STUDY TITLE

This is to inform you that JOOTRH ISERC has reviewed and **approved** your above research proposal. Your application approval number is **ISERC/JOOTRH/746/23.** The approval period is 22nd March, 2024 to 22nd March, 2025.
This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by JOOTRH ISERC.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to JOOTRH ISERC within 72 hours of notification
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to JOOTRH ISERC within 72 hours.
v. Clearance for export of biological specimens must be obtained from relevant institutions.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to JOOTRH ISERC.
viii. In case the study site is JOOTRH, kindly report to Chief Executive Officer before commencement of data collection.
ix. Prior to commencing your study, you will be expected to obtain a research license from National Commission for Science, Technology and Innovation (NACOSTI) https://research-portal.nacosti.go.ke and also obtain other clearances needed.

Yours sincerely,

JOOTRH ETHICS & REVIEW COMMITTEE
P. O. Box 849 - 40100
KISUMU

ANTONY AYORA
SECRETARY – ISERC
JOOTRH - KISUMU

COUNTY GOVERNMENT OF KISUMU
DEPARTMENT OF MEDICAL SERVICES, PUBLIC HEALTH AND SANITATION

Telephone: 057-2020801/2020803/2020321
Fax: 057-2024337
E-mail: medsuptnpgh@yahoo.com
ceo@jaramogireferral.go.ke
Website: www.jaramogireferral.go.ke
When replying please quote

JARAMOGI OGINGA ODINGA TEACHING & REFERRAL HOSPITAL
P.O. BOX 849-40100
KISUMU

Ref. No: GEN/21A

Date: 17th May, 2024

TO: Regina Kanini Ikindu

Dear Regina

RE: PERMISSION TO COLLECT DATA

Following approval of protocol titled "Evaluation of Cardiac Troponin I Levels in Chronic Kidney Patients Undergoing Haemodialysis at Jaramogi Oginga Odinga Teaching and Referral Hospital, Kisumu County-Kenya", you are hereby permitted to proceed with the activity.

Thank you.

Yours

CHIEF EXECUTIVE OFFICER
JARAMOGI OGINGA ODINGA
TEACHING & REFERRAL
HOSPITAL (JOOTRH)
P. O. BOX 849 - 40100
KISUMU
DATE:

DR. RICHARD LESIYAMPE
CHIEF EXECUTIVE OFFICER
JOOTRH – KISUMU

Appendix VI: permit license from NACOSTI

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: 508026

Date of Issue: 17/April/2024

RESEARCH LICENSE



This is to Certify that Ms.. REGINA KANINI IKINDU of Maseno University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Kisumu on the topic: EVALUATION OF CARDIAC TROPONIN I LEVELS IN CHRONIC KIDNEY DISEASE PATIENTS UNDERGOING HAEMODIALYSIS AT JARAMOGI TEACHING AND REFERRAL HOSPITAL, WESTERN KENYA. for the period ending : 17/April/2025.

License No: NACOSTI/P/24/34424

508026

Applicant Identification Number

Director General
NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Verification QR Code

NOTE: This is a computer generated License. To verify the authenticity of this document, Scan the QR Code using QR scanner application.

See overleaf for conditions