FACTORS ASSOCIATED WITH MORTALITY AMONG SEVERELY ILL COVID-19 PATIENTS, NAIROBI METROPOLIS, KENYA

BY

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RESEARCH REPORT SUBMITTED IN PARTIAL FULFILMENT OF THE REQUIREMENT OF THE DEGREE OF MASTER OF PUBLIC HEALTH OF MOI UNIVERSITY

DECLARATION

Declaration by Candidate

This report is my original work and has not been presented to any other university/institution”

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ABBREVIATIONS

ARDS	Acute Respiratory Distress
CFR	Case Fatality Rate
COVID-19	Coronavirus Disease 2019
CRP	C-reactive protein
DM	Diabetes mellitus
HDU	High Dependency Units
ICU	Intensive Care Unit
ILI	Influenza-Like-Illness
IREC	Institutional Research and Ethics Committee
K-FELTP	Kenya Field Epidemiology and Laboratory Training Program
kPa	Kilopascal
MERS	Middle East Respiratory Syndrome
mmHg	Millimeters of Mercury
MODS	multi-organ failure
NLR	Neutrophil-Lymphocyte Ratio
NM	Nairobi Metropolis
PaO2/FiO2	Partial Pressure of oxygen (Fraction of inspired oxygen)
RNA	Ribonucleic Acid
RR	Respiratory Rate
RT-PCR	Real Time-Polymerase Chain Reaction
SARS	Severe Acute Respiratory Syndrome
SARS-COV2	Severe Acute Respiratory Syndrome- Coronavirus 2
SITREP	Situational Report
SOFA	Sequential Organ Failure Assessment

SPO_2	Oxygen Saturation
UK	United Kingdom
WBC	White Blood Cell count
WHO	World Health Organization

KEY DEFINITIONS

Severe COVID-19 Patient- any patient with positive RT-PCR for Covid-19 and with any of the following: respiratory rate (RR) of >30 breaths per minute (BpM), measured oxygen concentration of <94% (SPO_2), oxygenation index (PaO2/FiO2) ≤300 mmHg (1 mmHg = 0.133 kPa); lung imaging tests showing significant progression (>50%) in lesions in 24–48 hours; age >50 years and Neutrophil-Lymphocyte Ratio (NLR) ≥3.13; respiratory failure and need for mechanical ventilation (non-invasive or invasive ventilator); shock; and Comorbid failure in other organs and need for ICU monitoring and treatment (6) (98). These parameters were considered at the point of admission and during isolation.

Fever- symptom reported by the patient or recorded temperature equal to or more than 38ºC.

Comorbidity- the presence of any known or newly diagnosed underlying chronic condition, e.g., diabetes mellitus, hypertension, asthma, etc, at the point of admission or during the hospital stay.

Laboratory tests- defined by their normal ranges (meaning that any test is within its normal range, increased or decreased).

Normal Ranges:

Hemoglobin- 12─18g/dl,

White Blood Cell count (WBCs) - 4000─11000 per microliter (mcL),

Neutrophils- 1500─7000/mcL,

Lymphocyte- 1000─4000/mcL,

C-Reactive Protein- <10 mg/L,

Urea- 2─8 mmol/L,

Creatinine- 60─130 micromol/L,

Alanine and aminotransferase- 0-40 units/L,

Sodium levels- 135─145 mEq/L and

Potassium- 3.3─5.4mmol/L.

Clinical complications- determined from the clinical notes as recorded by the clinician.

ABSTRACT

Background: Severe Coronavirus Disease 2019 (COVID-19) occurs in about 20% of hospitalized patients. Many of these patients have comorbidities and are the main contributors for COVID-19 mortality. The most common underlying conditions include hypertension, diabetes, and chronic lung disease.

Objectives: To describe socio-demographic factors of severe COVID-19 patients; determine the clinical, laboratory, and radiological characteristics and outcomes of severe COVID-19 disease; and evaluate the predictors of mortality for severely ill COVID-19 patients.

Methods: A cross-sectional study in Nairobi Metropolis was conducted between September and December 2021. Patient information was collected from the inpatient registers of selected hospitals with COVID-19 isolation centers. This included demographic and clinical information, presenting signs and symptoms, laboratory and radiological findings during hospitalization, and case management. A severe COVID-19 patient was defined as any COVID-19 patient with any of the following: oxygen saturation <94% in room air, respiratory rate >30 breaths/minute, and any signs of respiratory distress such as difficulty in breathing, or rapid breathing, confusion, reduced blood pressure, low blood oxygen, and tiredness. Mortality (case) was defined as any patient with severe COVID-19 infection who died, as recorded and reported by the hospital. Non-case was defined as any patient who survived a severe COVID-19 infection. Means and medians were calculated for continuous variables, and frequencies and proportions for categorical variables. Chi-square and multivariable binary logistic regression compared exposure factors with disease outcome. The study proposal was approved by Moi University Institutional Research Ethics Committee (IREC).

Results: Total abstracted records were for 818 patients; 500 (61%) severe patients (153 non-survivors, 347 survivors). The analysis involved 150 non-survivors and 150 survivors. Males were 66.8%, and a mean age of 53.29 years ± 17.7. Sixty-four (64.3) percent presented with difficulty breathing, cough 63.7%, while 33.3% had a fever. Patients with Peripheral Oxygen Saturation (SPO2) of ≤94% were 39.9% at admission, rising to 90.0% during isolation. Patients with underlying diabetes were 29.3%, while hypertension/heart disease was 28.3%. Patients that developed acute respiratory distress syndrome (ARDS) were 26.0%. Patients put on oxygen therapy were 28.3%, mechanical ventilation 19.3%, and ICU admissions were 3.7%. Factors significantly associated with death were: hypertension (OR-3.5, 95% CI- 1.34–9.45, p-value- 0.011); ARDS (OR- 8.9, 95% CI- 3.05–26.14, p-value- <0.001); severe disease at admission (OR- 18.7, 95% CI- 5.24–67.15, p-value <0.001); and failure to receive oxygen treatment (OR- 17.5, 95% CI- 5.54–55.32, p-value <0.001).

Conclusion: The results highlighted that advanced age, hypertension, hypoxia at admission, and lack of oxygen therapy were independently associated with increased risk of death. These findings are consistent with international evidence, yet they also reflect unique health system challenges within the Kenyan context.

Recommendation: We recommend that the government of Kenya, through the Ministry of Health, should: enhance early risk stratification and triage, scale up oxygen supply and infrastructure, expand intensive care capacity, and improve management of non-communicable diseases, among others.

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CHAPTER ONE

1.0 Introduction

The Coronavirus Disease 2019 (COVID-19), caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), has evolved into one of the most significant global public health crises of the 21st century. As of early 2025, more than 700 million people globally have contracted the virus, with over 7 million deaths reported (World Health Organization [WHO], 2024). The impact has been particularly severe in regions with fragile health systems and limited access to critical care services.

World Health Organization (WHO) defines Severe Acute Respiratory Syndrome (SARS) as anyone presenting within ten days of an acute respiratory illness that is severe, with symptoms that include fever, cough, difficulty in breathing, and requiring hospitalization (Smith D et al., 2017). SARS is associated with many microorganisms, which contain both viruses and bacteria. COVID-19 is a form of SARS caused by coronavirus 2 (SARS-COV2). The SARS-COV2 outbreak was first reported in Wuhan, China, in December 2019 and declared by the World Health Organization (WHO) a pandemic on 11th March 2020. SARS-COV2 infection ranges from asymptomatic to mild disease with Influenza-Like-Illness (ILI) to severe disease presenting with respiratory distress, requiring hospitalization, and may result in organ failure and death (2). Transmission is through aerosols from an infected person or contact with infected surfaces, transferred to the mouth, eyes, and nose after touching contaminated hands. This mode of transmission means that to control the spread of this disease, the traditional methods of public health disease prevention and control, such as treatment of cases, vector control, etc. are less effective on their own as most disease carriers present with no symptoms (Sun J et al, 2020).

In Kenya, the initial wave of COVID-19 disproportionately affected urban centers, particularly Nairobi Metropolis. With its high population density, major transport hubs, and extensive international links, Nairobi became a primary hotspot. Despite public health interventions including lockdowns, social distancing, and mask mandates, severe cases continued to strain the healthcare system. By the end of 2020, over 96,000 confirmed cases and 1,670 deaths had been reported in Kenya, with the Nairobi Metropolis accounting for more than half of both case burden and fatalities (Ministry of Health [MOH], 2021).

Severe COVID-19 is characterized by respiratory distress, hypoxia, organ dysfunction, and in some cases, a cytokine storm leading to multi-organ failure. Predictors of severe illness and death have been reported globally and include advanced age, comorbidities such as hypertension, diabetes, and heart disease, and delayed access to critical interventions like oxygen therapy and intensive care unit (ICU) support (Guan et al., 2020; Richardson et al., 2020).

Severe COVID-19 presents a more significant challenge to public health systems due to factors like the availability of the required infrastructure to manage such cases. This infrastructure would include Intensive Care Units (ICU), High Dependency Units (HDU), and oxygen supply, etc., required to manage these patients. Among all hospitalized COVID-19 patients, different populations have shown different proportions of the severe form of the disease. A study by ***Richardson et al***. on the '***Presenting Characteristics, Comorbidities, and Outcomes Among 5700 Patients Hospitalized With COVID-19 in the New York City Area'*** showed a 26% of all hospitalized COVID-19 patients have a more severe disease requiring Intensive Care Unit (ICU) admission, and 28% mortality (Richardson S et al., 2020). A range of 16-

78% best presents mortality from severe COVID-19 from some of the published case series from different populations worldwide (Bonanomi E et al., 2020). This proportion is high compared to the overall case fatality rate (CFR) of 2.2% as of 16th January 2021 (WHO EMRO, 2021). Severe cases, therefore, contribute to the highest case-load of mortality and are resource-intensive to manage.

1.2 Problem statement

The initial wave of COVID-19 in Kenya, like global trends, saw a significant number of deaths, with patients often presenting with severe breathing difficulties before succumbing to the disease, as seen in a study done at the start of the pandemic in Nairobi and Mombasa, Kenya (Charles Mulwa Muendo et al., 2022). These patients frequently developed acute respiratory distress syndrome (ARDS) and organ malfunction, highlighting the urgent need for more intensive care unit (ICU) facilities to manage critically ill individuals (Charles Mulwa Muendo et al., 2022). This study informed the initiation of a follow-up study aimed at understanding the factors influencing mortality among severely ill COVID-19 patients in Kenya, specifically in the Nairobi Metropolis. A previous study (Loice Achieng Ombajo et al., 2021) identified that 11% of COVID-19 patients in Kenya were severely ill and required ICU care.

Although numerous global studies have identified risk factors for severe illness and mortality from COVID-19, there is a lack of context-specific data from Kenya, particularly in urban settings like Nairobi. Factors such as socio-demographic variations, disparities in access to care, pre-existing comorbidities, and hospital-level resources may influence outcomes in severely ill patients. The absence of localized data limits the ability to implement targeted interventions and allocate resources efficiently.

Thus, there is an urgent need to investigate and document the determinants of mortality among severely ill COVID-19 patients in Nairobi Metropolis.

1.3 Justification

Understanding the risk factors associated with COVID-19 mortality in severely ill patients is crucial for clinical decision-making and public health planning. Nairobi Metropolis is the epicenter of Kenya's COVID-19 burden, yet local studies remain limited. By identifying predictors of mortality, this study will support the development of clinical protocols, improve patient outcomes, and inform resource allocation and emergency preparedness in similar urban settings. Furthermore, findings from this study will provide valuable insights for future epidemic responses in Kenya and similar low- and middle-income countries.

Understanding these factors is critical not only for refining clinical management protocols but also for informing public health strategies aimed at improving outcomes in future pandemics or surges.

Why Nairobi Metropolis? Nairobi is the capital city and the business hub of Kenya. The capital draws its workforce from within and the neighboring counties. Since the start of the COVID-19 pandemic, Nairobi County and its neighbors (Metropolis) have recorded the highest number of COVID-19 patients. Nairobi metropolis has major entry points into the country, including Jomo Kenyatta International Airport (JKIA), Wilson Airport, and the Namanga border entry. The Kenya-Tanzania, Namanga port of entry, had become very important for Tanzania had instituted no control measure against COVID-19 spread (14).

1.4 Research Question

What are the socio-demographic, clinical, and healthcare-related factors associated with mortality among severely ill COVID-19 patients in Nairobi Metropolis?

1.5 Objectives

1.5.1 General Objective

To determine factors associated with mortality among severe Coronavirus Disease-2019 (COVID-19) patients, Nairobi Metropolis.

1.5.2 Specific Objective

1. To describe the socio-demographic characteristics of severely ill COVID-19 patients in Nairobi Metropolis within 10 months (from March 2020 to December 2020), focusing on factors such as age, gender, and comorbidities, by reviewing patient records.
2. To determine the clinical, laboratory, and radiological characteristics and outcomes of severely ill COVID-19 patients in Nairobi Metropolis by analyzing medical and laboratory data of patients within 10 months, identifying the key indicators associated with disease progression and patient outcomes.
3. To evaluate the predictors of mortality among severely ill COVID-19 patients in Nairobi Metropolis by performing statistical analyses of patient data from March to December 2020, identifying significant clinical, laboratory, and socio-demographic variables that correlate with mortality.

CHAPTER TWO

2.0 Literature Review

2.1 Introduction

The COVID-19 pandemic has emerged as a global health crisis, significantly impacting health systems worldwide. In Kenya, the virus has affected various regions differently, with the Nairobi Metropolis area comprising Nairobi, Machakos, Kajiado, and Kiambu being at the forefront of the country's response to the pandemic. These areas, characterized by a large urban population and diverse socio-economic status, face unique challenges in the fight against COVID-19. As of 2021, Kenya has seen a considerable number of COVID-19 cases and deaths, with Nairobi Metropolis serving as the epicenter.

While much attention has been paid to the global mortality rate of COVID-19, local studies focusing on the socio-demographic, clinical, laboratory, and radiological factors that contribute to mortality among severely ill patients in Kenya, particularly in Nairobi Metropolis, remain sparse. This literature review aims to explore the factors associated with mortality among severely ill COVID-19 patients in Nairobi Metropolis by synthesizing global evidence and relevant data from Kenya. By identifying these factors, the study will provide insights into local public health needs and guide interventions for reducing mortality in the region.

2.2 Socio-Demographic Factors

2.2.1Age and Mortality Risk

Age is widely regarded as a major determinant of the severity and outcome of COVID-19. Globally, older adults, especially those aged 60 years and above, have experienced the highest mortality rates. A study by Wu et al. (2020) found that the mortality rate for patients over 70 years of age was significantly higher than for those under 50 years. This trend is similarly observed in Kenya, with a study conducted by Muendo et al. (2021) in Nairobi showing that older patients were at greater risk of poor outcomes. This may be due to age-related immunosenescence, which reduces the ability of older adults to fight off infections.

In Kenya, the demographic structure, with a growing aging population, means that the elderly are more vulnerable to COVID-19. Additionally, the occurrence of co-morbidities such as hypertension and diabetes which are more prevalent in older adults further complicates the management of COVID-19 in this population.

2.2.2 Gender Differences

Gender has been identified as another important socio-demographic factor influencing COVID-19 mortality. Multiple studies, including those by Madjid et al. (2020) and Chen et al. (2020), have consistently found that males are more likely to experience severe illness and death from COVID-19 compared to females. The higher risk among males is thought to be due to a combination of biological, behavioral, and social factors. Biological differences in immune responses, coupled with higher rates of comorbidities such as cardiovascular diseases and smoking among men, may contribute to this disparity.

In the context of Nairobi Metropolis, gender differences in health outcomes are compounded by social determinants such as access to healthcare and health-seeking behavior. Men are often less likely to seek timely medical attention, and this delay can lead to poor outcomes, particularly in COVID-19 patients.

2.3 Socio-Economic Status

Socio-economic status plays a crucial role in determining the risk of severe illness and mortality from COVID-19. Individuals from lower socio-economic backgrounds, especially those living in informal settlements with poor living conditions and overcrowding, face a higher risk of contracting COVID-19. Studies have shown that individuals in such communities have limited access to healthcare, insufficient sanitation, and a higher prevalence of comorbidities, all of which increase the likelihood of severe COVID-19 outcomes (Wang et al., 2020).

In Nairobi, where a significant portion of the population lives in informal settlements such as Kibera and Mathare, the rapid spread of COVID-19 and increased mortality in these areas is attributed to overcrowding, lack of access to healthcare, and limited public health resources (UNICEF, 2020). The COVID-19 pandemic has exacerbated these disparities, with the most vulnerable groups suffering disproportionately.

2.4 Clinical Characteristics and Co-Morbid Conditions

2.4.1 Hypertension

Hypertension is one of the most common comorbidities found in severely ill COVID-19 patients and is strongly associated with an increased risk of mortality. Studies such as those by Zhou et al. (2020) and Sattar et al. (2020) have consistently demonstrated that hypertensive patients are more likely to experience severe disease and die from COVID-19. This is due to the adverse effects of hypertension on the cardiovascular system, which may exacerbate respiratory complications such as ARDS, a common outcome in severe COVID-19 cases.

In Nairobi Metropolis, hypertension is prevalent, particularly in older adults, and is frequently associated with other conditions such as diabetes and obesity, which further compound the risk of severe COVID-19 outcomes (Muendo et al., 2021). Hypertension's role in COVID-19 mortality underscores the need for early detection and management of hypertension in the population, particularly in high-risk groups.

2.4.2 Diabetes Mellitus

Diabetes mellitus has also been identified as a major risk factor for severe COVID-19 illness. Diabetic patients have impaired immune responses, which make them more susceptible to infections and complications. The presence of diabetes is associated with an increased likelihood of requiring intensive care, mechanical ventilation, and a higher risk of death from COVID-19 (Alzahrani et al., 2021). In Kenya, the prevalence of diabetes is rising, particularly in urban areas such as Nairobi, which is seeing increased rates of obesity, sedentary lifestyles, and poor dietary habits.

Muendo et al. (2021) noted that diabetic patients in Nairobi Metropolis had significantly higher mortality rates compared to non-diabetic patients. The risk of severe outcomes in diabetic COVID-19 patients can be mitigated through better diabetes management, including monitoring blood glucose levels and early interventions for complications.

2.4.3 Obesity

Obesity has been identified as a key risk factor for severe COVID-19 outcomes, as it leads to a pro-inflammatory state, increases the risk of respiratory failure, and impairs immune function. A study by Sattar et al. (2020) showed that individuals with a body mass index (BMI) above 30 are at a higher risk of developing severe COVID-19 and experiencing poor outcomes, including death. This is due to several factors, including the mechanical effects of obesity on ventilation and the increased systemic inflammation associated with excess fat tissue.

In Nairobi, obesity is becoming an increasingly prevalent risk factor, driven by urbanization, poor dietary choices, and a lack of physical activity. Studies in Nairobi's urban centers have found that a significant proportion of the population is overweight or obese, putting them at risk of severe COVID-19 outcomes (Wang et al., 2020). Addressing the obesity epidemic through lifestyle interventions and public health campaigns is critical to mitigating COVID-19 mortality risk.

2.5 Laboratory Findings and Blood Markers

2.5.1 C-Reactive Protein (CRP)

CRP is an acute-phase protein that rises in response to inflammation and infection. Elevated CRP levels have been strongly associated with severe COVID-19 disease and mortality (Lippi et al., 2020). In COVID-19 patients, CRP is used as an indicator of systemic inflammation and is correlated with disease severity and complications such as ARDS and multi-organ failure. Studies have shown that patients with high CRP levels at admission are more likely to require intensive care and experience poor outcomes (Zhou et al., 2020).

In Nairobi, CRP levels have been widely used as part of the diagnostic and prognostic assessment for COVID-19 patients. Elevated CRP is particularly common in patients with co-morbidities such as hypertension and diabetes, further highlighting the role of inflammation in COVID-19 mortality (Muendo et al., 2021).

2.5.2 D-Dimer and Coagulation Disorders

Coagulation abnormalities, including elevated D-dimer levels, have been linked to severe COVID-19 disease and increased mortality. D-dimer is a fibrin degradation product that indicates the presence of thrombus formation, which is common in COVID-19 patients due to the hypercoagulable state induced by the virus. Studies have found that elevated D-dimer levels are associated with poor outcomes, including the development of venous thromboembolism and ARDS (Zhou et al., 2020).

In Nairobi, D-dimer testing has become an important component of the clinical evaluation of COVID-19 patients, especially those presenting with severe respiratory symptoms. Elevated D-dimer levels are often seen in patients with severe disease and are predictive of worse outcomes (Muendo et al., 2021). Thrombotic complications in COVID-19 necessitate early intervention with anticoagulation therapy, especially in high-risk patients.

2.6 Radiological Features

2.6.1 Chest X-Ray and Computed Tomography (CT)

Chest imaging, including CT scans and X-rays, plays a crucial role in assessing the severity of COVID-19 pneumonia. CT scans have shown high sensitivity for detecting pulmonary involvement in COVID-19 patients. Common findings include ground-glass opacities and consolidation, which are indicative of viral pneumonia and can be used to monitor disease progression (Li et al., 2020). These radiological features are often correlated with clinical severity and can help predict the need for intensive care.

In Nairobi, where CT scan availability may be limited, chest X-rays are commonly used for early diagnosis. While not as sensitive as CT, chest X-rays can reveal key features such as infiltrates and consolidation, which are indicative of worsening disease. Early identification of these radiological changes allows for timely interventions that can reduce the risk of mortality.

2.7 Clinical Management of Severe COVID-19 Patients

2.7.1 Overview of Clinical Management Strategies

The management of severely ill COVID-19 patients has evolved rapidly since the emergence of the virus in late 2019. Early clinical management strategies focused on supportive care, including oxygen therapy and mechanical ventilation, while newer approaches have incorporated pharmacological treatments, immunomodulatory therapies, and advanced technologies to reduce mortality and improve patient outcomes (WHO, 2020). In severe cases of COVID-19, where the risk of mortality is high, it is essential to apply evidence-based management protocols to mitigate complications such as acute respiratory distress syndrome (ARDS), sepsis, and multi-organ failure.

Clinical management strategies for COVID-19 have been developed based on emerging evidence from global studies, with tailored approaches for different health systems. In high-resource settings, the application of advanced medical interventions such as extracorporeal membrane oxygenation (ECMO), corticosteroid therapy, and the use of antivirals like remdesivir have significantly improved the outcomes for critically ill patients. In resource-limited settings, such as Kenya, where healthcare resources are stretched, the primary focus remains on early recognition of severe cases, supportive care, and the judicious use of available therapies (Muendo et al., 2021).

2.7.2 Supportive Care and Oxygen Therapy

Oxygen therapy is one of the cornerstones of clinical management for patients with severe COVID-19, especially those with hypoxemia (low blood oxygen levels). In the early stages of the pandemic, it was quickly recognized that COVID-19 can cause severe pulmonary complications, particularly pneumonia, which results in low oxygen saturation levels and respiratory failure. Patients with oxygen saturation levels below

94% in room air are considered at high risk of deteriorating to severe disease and require early intervention with supplemental oxygen (Lippi et al., 2020).

In Nairobi Metropolis, where hospitals are often overwhelmed during peak surges, oxygen therapy has become essential in the management of severely ill COVID-19 patients. Many hospitals in Nairobi have expanded their oxygen capacity, and supplemental oxygen is administered through nasal prongs or high-flow oxygen systems, depending on the severity of the patient's condition. For patients in critical condition with ARDS, mechanical ventilation or non-invasive ventilation (NIV) may be required, although mechanical ventilators remain in short supply in many Kenyan hospitals (Muendo et al., 2021).

The World Health Organization (WHO) has recommended that patients with severe hypoxemia should receive oxygen therapy early to prevent organ damage. The rapid escalation of oxygen therapy, particularly through high-flow nasal cannulas, has been associated with improved survival rates in severe cases of COVID-19 (National Institutes of Health [NIH], 2021).

2.7.3 Pharmacological Treatments

The management of COVID-19 has involved various pharmacological interventions designed to target viral replication, reduce inflammation, and prevent complications such as thrombosis. Some of the key pharmacological agents used include:

- Antiviral Drugs: Remdesivir, an antiviral drug initially developed for Ebola, has been used in the treatment of COVID-19 patients to inhibit the replication of the SARS-CoV-2 virus. Studies have shown that remdesivir can reduce the duration of symptoms and improve recovery times in hospitalized patients with moderate to severe disease (Beigel et al., 2020). However, its use in resource-limited settings such as Nairobi is constrained by cost and availability.

- Corticosteroids: Dexamethasone, a corticosteroid, has been shown to significantly reduce mortality in critically ill COVID-19 patients who require mechanical ventilation or supplemental oxygen. The RECOVERY trial (2020) found that dexamethasone reduced the risk of death by one-third in patients requiring invasive mechanical ventilation. As a result, dexamethasone has become a standard part of treatment protocols in many countries, including Kenya, for severe cases of COVID-19.

- Monoclonal Antibodies and Convalescent Plasma: In more severe cases, monoclonal antibodies, such as casirivimab and imdevimab, are used in some countries to neutralize the virus. Convalescent plasma, collected from individuals who have recovered from COVID-19, has also been tested as a potential treatment, although its effectiveness remains uncertain. In Kenya, the use of monoclonal antibodies and convalescent plasma is still under evaluation, and these therapies are not yet widely accessible (Lippi et al., 2020).

- Anticoagulants: Given the increased risk of thrombotic events in COVID-19 patients, especially those with elevated D-dimer levels, the use of anticoagulants such as low molecular weight heparin (LMWH) is recommended in severe cases to prevent deep vein thrombosis (DVT) and pulmonary embolism (Zhou et al., 2020). This is particularly important in patients who are immobile or have been on mechanical ventilation.

2.7.4 Immunomodulatory Therapies

Immunomodulatory therapies are designed to modulate the body's immune response to the SARS-CoV-2 virus. Severe COVID-19 cases often involve an exaggerated immune response, referred to as a "cytokine storm," which can lead to widespread tissue damage and multi-organ failure. Immunomodulatory drugs are used to reduce this inflammatory response.

- IL-6 Inhibitors: Drugs that inhibit interleukin-6 (IL-6), such as tocilizumab, are increasingly used to treat COVID-19 patients with severe disease. IL-6 is a cytokine that plays a critical role in inflammation, and its inhibition has been associated with reduced mortality in critically ill patients (Huang et al., 2020). However, the availability of IL-6 inhibitors in Nairobi is limited, and their use is typically reserved for patients who meet specific clinical criteria.

- JAK Inhibitors: Janus kinase (JAK) inhibitors, such as baricitinib, are another class of immunomodulatory drugs that have been shown to reduce the severity of COVID-19. JAK inhibitors work by blocking the JAK-STAT signaling pathway, which is involved in the inflammatory response. While effective, the cost and availability of JAK inhibitors in Nairobi make them less accessible in many public health facilities.

2.7.5 Managing Complications

Severe COVID-19 can lead to several life-threatening complications, including ARDS, septic shock, acute kidney injury (AKI), and multi-organ failure. The management of these complications requires prompt recognition and appropriate interventions.

- Acute Respiratory Distress Syndrome (ARDS): ARDS is a common complication in severe COVID-19 and is characterized by severe hypoxemia and bilateral lung infiltrates. The management of ARDS includes lung-protective ventilation strategies such as low tidal volume ventilation and prone positioning. Prone positioning, where the patient is turned onto their abdomen, has been shown to improve oxygenation in patients with severe ARDS (Sud et al., 2020).

- Sepsis and Septic Shock: Sepsis is a life-threatening condition that occurs when the body's response to infection leads to widespread inflammation, organ dysfunction, and low blood pressure. COVID-19 patients are at high risk of developing sepsis due to secondary bacterial infections or viral-induced damage to organs. Early identification and appropriate use of antibiotics, as well as fluid resuscitation, are key components of managing sepsis in COVID-19 patients.
- Acute Kidney Injury (AKI): AKI is another common complication, especially in critically ill COVID-19 patients. The use of nephrotoxic drugs, prolonged hypoxia, and the direct effects of SARS-CoV-2 on the kidneys can lead to kidney dysfunction. Dialysis may be required in severe cases (Lippi et al., 2020). In Nairobi, the availability of dialysis services is limited, and kidney injury management often relies on early recognition and supportive care.

2.7.6 Role of Telemedicine and Remote Monitoring

Telemedicine has become increasingly important in the management of COVID-19, particularly in resource-limited settings. Remote monitoring allows healthcare providers to track the progression of COVID-19 symptoms, adjust treatment regimens, and reduce patient exposure to the virus. In Nairobi, telemedicine platforms have been utilized to follow up with COVID-19 patients who are either recovering at home or undergoing mild to moderate treatment in isolation centers. Telemedicine also provides a way to provide ongoing support for patients in remote areas with limited access to healthcare facilities.

2.7.7 The Role of Vaccination in Reducing Mortality

While vaccination efforts have primarily targeted prevention, the broader public health goal of reducing COVID-19 mortality is heavily reliant on the rapid and widespread deployment of vaccines. Vaccines have been shown to significantly reduce the risk of severe illness, hospitalization, and death in individuals who contract COVID-19 after vaccination (Polack et al., 2020). In Kenya, vaccination campaigns have been rolled out in major urban centers, including Nairobi, to protect high-risk populations and frontline workers. Continued vaccination efforts are essential for reducing the strain on healthcare systems and preventing future waves of severe disease.

2.8 Conclusion

The factors associated with mortality in severely ill COVID-19 patients are multi-faceted and include socio-demographic, clinical, laboratory, and radiological variables. In Nairobi Metropolis, older age, male gender, low socio-economic status, and co-morbidities such as hypertension, diabetes, and obesity significantly increase the risk of severe disease and death. Laboratory markers, such as CRP, D-dimer, and lymphocyte counts, offer valuable prognostic information, while radiological assessments help clinicians gauge the severity of pulmonary involvement and guide treatment decisions. Understanding these factors is crucial for improving patient outcomes and guiding public health interventions aimed at reducing COVID-19 mortality in Nairobi Metropolis.

2.9 Conceptual Framework

Introduction to the Conceptual Framework

A conceptual framework serves as the foundation for the design of a research study by outlining the key variables, their relationships, and guiding the methodology. In the context of this study on the factors associated with mortality among severely ill COVID-19 patients in Nairobi Metropolis, the conceptual framework identifies and illustrates how socio-demographic, clinical, laboratory, and radiological factors interact to influence patient outcomes. This framework not only helps in understanding the variables to be considered but also informs the selection of appropriate research methods and tools.

The conceptual framework for this study is guided by a multifactorial approach that recognizes the complex interactions between various factors that influence mortality in COVID-19 patients. Given that mortality is a multifaceted phenomenon, it is critical to understand how these diverse factors—ranging from patient demographics and pre-existing health conditions to clinical presentation and therapeutic interventions—can either mitigate or exacerbate the severity of the disease and its outcomes.

Key Constructs and Variables

The conceptual framework for this study is centered on four major categories: socio-demographic factors, clinical characteristics and comorbidities, laboratory findings, and radiological features. These categories will be the primary constructs that are explored, with a focus on their relationships to mortality among severely ill COVID-19 patients in Nairobi Metropolis.

2.9.1 Socio-Demographic Factors

Socio-demographic factors, which include age, gender, and socio-economic status, are foundational variables in this framework. These factors are considered primary determinants of health outcomes and are hypothesized to directly influence the severity of illness and risk of death in COVID-19 patients.

- **Age**: Older age has been consistently associated with an increased risk of severe disease and mortality in COVID-19 patients (Wu et al., 2020). The likelihood of mortality increases as patients age, with those over 60 at the highest risk.
- **Gender**: Males have been shown to experience higher mortality rates compared to females in COVID-19 (Madjid et al., 2020). This difference is attributed to both biological and behavioral factors, including differences in immune responses and health-seeking behaviors.
- **Socio-Economic Status (SES)**: Patients from lower socio-economic backgrounds, especially those living in informal settlements, are more likely to experience adverse outcomes. Factors such as overcrowding, limited access to healthcare, and high rates of comorbidities are significant contributors to the increased risk of mortality in these groups (Muendo et al., 2021).

2.9.2 Clinical Characteristics and Comorbidities

Clinical characteristics and pre-existing comorbidities are critical mediators of disease progression in COVID-19 patients. This category captures the underlying health conditions that interact with the SARS-CoV-2 infection, affecting how the body responds to the virus and the severity of the disease.

- **Hypertension**: Hypertension is one of the most common comorbidities associated with severe COVID-19 outcomes (Zhou et al., 2020). The chronic inflammatory state caused by hypertension exacerbates respiratory complications and increases the likelihood of multi-organ failure.

- **Diabetes Mellitus**: Diabetes is another comorbidity that has been linked to poor COVID-19 outcomes. Diabetic patients have a weakened immune system, making them more susceptible to complications and prolonged disease progression (Alzahrani et al., 2021).
- **Obesity**: Obesity is a risk factor for severe COVID-19 as it contributes to increased inflammation, impaired lung function, and metabolic disturbances (Sattar et al., 2020). Individuals with a BMI greater than 30 are at a higher risk of developing severe disease and complications, including respiratory failure.
- **Other Clinical Features**: Respiratory distress, fever, and oxygen saturation levels are significant indicators of disease severity. These clinical signs serve as predictors of mortality in COVID-19 patients.

2.9.3Laboratory Findings

Laboratory tests provide crucial insights into the severity and progression of COVID-19, helping clinicians to assess the patient's overall condition and predict the likelihood of poor outcomes. The role of laboratory findings, such as inflammatory markers, coagulation tests, and blood counts, is central to this framework.

- **C-Reactive Protein (CRP)**: CRP levels are elevated in response to systemic inflammation. Higher CRP levels have been shown to correlate with disease severity and poor prognosis (Lippi et al., 2020).
- **D-Dimer**: Elevated D-dimer levels indicate thrombotic activity, which is common in severe COVID-19 cases and is associated with an increased risk of mortality (Zhou et al., 2020).

- **Lymphocyte Count**: Lymphopenia, or low lymphocyte count, is a characteristic feature of severe COVID-19 and is associated with an increased risk of mortality (Tan et al., 2020). It reflects immune system dysregulation and a poor prognosis.

2.9.4 Radiological Features

Radiological imaging is essential in evaluating the extent of pulmonary damage in COVID-19 patients. Chest X-rays and CT scans are used to identify complications such as pneumonia, lung consolidation, and ground-glass opacities, which are indicative of viral infection.

- **Chest X-ray and CT Scans**: Ground-glass opacities and bilateral lung infiltrates are common findings in severe COVID-19 cases and correlate with poor outcomes (Li et al., 2020). The severity of these findings can guide clinical decision-making, particularly in determining the need for advanced respiratory support.

2.9.5 Relationships and Pathways in the Conceptual Framework

The framework proposes a multi-directional relationship between the identified constructs and COVID-19 mortality. The interactions among socio-demographic factors, clinical characteristics, laboratory findings, and radiological features are believed to influence mortality in several ways:

1. **Socio-Demographic Factors and Clinical Outcomes**: Socio-demographic factors such as age, gender, and socio-economic status can predispose individuals to worse health outcomes by affecting access to healthcare, exposure to the virus, and the presence of comorbidities (Muendo et al., 2021). Older adults, males, and those from lower socio-economic backgrounds may be

more likely to develop severe disease due to delayed presentation and lack of timely care.

2. **Clinical Characteristics and Laboratory Findings**: Comorbidities such as hypertension, diabetes, and obesity often result in abnormal laboratory findings, such as elevated CRP, D-dimer, and lymphocyte counts, which further increase the risk of mortality. For example, individuals with hypertension and diabetes are more likely to have high CRP levels, which correlate with worse outcomes in COVID-19 patients.
3. **Laboratory Findings and Radiological Features**: Elevated inflammatory markers such as CRP and D-dimer may be indicative of severe disease, which is often reflected in the radiological findings of the lungs. Chest imaging often shows signs of severe pneumonia, ARDS, or other complications that suggest a higher risk of mortality.
4. **Impact on Mortality**: These interconnected factors ultimately lead to an increased risk of mortality. For instance, patients with a combination of old age, co-morbidities, elevated inflammatory markers, and severe radiological findings are at the highest risk of death. This relationship emphasizes the importance of early identification and management to reduce the likelihood of severe outcomes.

2.9.6 Visual Representation of the Conceptual Framework

The following diagram visually represents the conceptual framework:

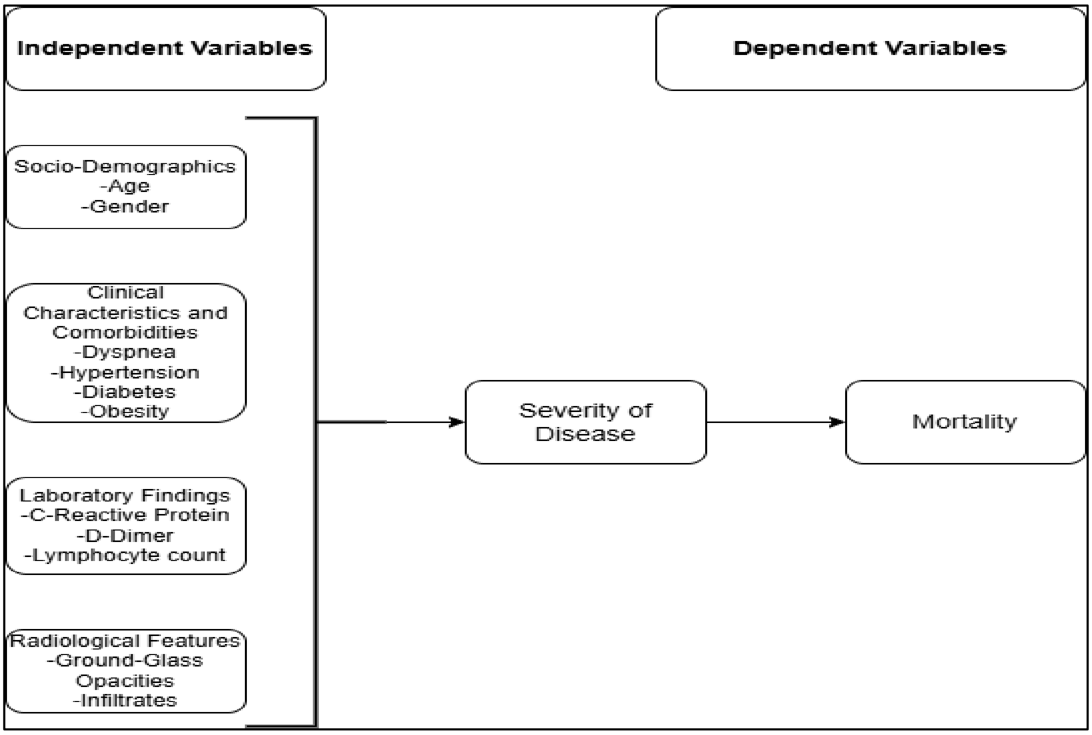

Figure 1. Conceptual framework

1. **Socio-Demographic Factors**
    - Age → Severity of Disease → Mortality
    - Gender → Severity of Disease → Mortality
    - Socio-Economic Status → Access to Healthcare → Mortality
2. **Clinical Characteristics and Comorbidities**
    - Hypertension, Diabetes, Obesity → Disease Progression → Mortality
3. **Laboratory Findings**
    - CRP, D-Dimer, Lymphocyte Count → Disease Severity → Mortality
4. **Radiological Features**
    - Ground-Glass Opacities, Infiltrates → Disease Severity → Mortality
5. **Outcome: Mortality in Severe COVID-19 Cases**

2.10 Conclusion

The conceptual framework presented in this study provides a comprehensive understanding of how socio-demographic factors, clinical characteristics, laboratory findings, and radiological features interact to influence mortality in severely ill COVID-19 patients in Nairobi Metropolis. By identifying these relationships, this framework helps to guide the research process, emphasizing the need for targeted interventions that address the multiple risk factors contributing to poor outcomes. The framework also highlights the complex nature of COVID-19 mortality, which is shaped by a multitude of factors, including health status, timely medical care, and access to resources.

CHAPTER THREE

3.0 Methods

3.1 Study site

The study site was selected hospitals within the Nairobi metropolis, carrying out isolation and clinical management for COVID-19 patients. Nairobi metropolis was defined as Nairobi County and areas in its immediate surroundings, as determined by the Metro 2030 strategy (91). These surrounding environs include towns and local governments within Machakos, Kiambu, and Kajiado counties. From the 2019 Kenya census, these four counties had a total population of 9,354,580 people, 20% of the Kenyan population (92). Nairobi County serves as the capital city of Kenya and is also its major commercial hub. The county is the home to Jomo Kenyatta International Airport, a major route for passengers from East Africa, other African nations, and all parts of the world. Most of the workforce for Nairobi County has their residents in Kiambu, Kajiado, and Machakos Counties. Kajiado County has a port of entry from Tanzania, with most travelers headed for Nairobi and beyond.

The Metropolis covers an area of approximately 32,000 Km^2 (93). Most of the workforce in Nairobi has their residences in Kiambu, Kajiado, and Machakos Counties. The area is made up of a cosmopolitan population, drawn from all the tribes within the country and visitors from outside the country. The area has a rapidly growing population, with unemployment being the major challenge (93). The main occupations of the people are industrial workforce, government workers, with farming, crop, and livestock, in the outskirts of towns. The area houses Kenya’s capital city, also serving as a major commercial and industrial hub for East and Central Africa. It is also the home to major local, regional, and global organizational headquarters like the United Nations.

NM is the home to major tourist attraction sites like the Nairobi National Park, Aberdares mountain ranges, Karura forest etc (93). This explains why most of the passenger traffic from East Africa and other African nations goes through the capital. Kajiado County has a port of entry from Tanzania, with most travelers headed for Nairobi and beyond. Due to high population growth and few social amenities, the area is characterized by many informal settlements (slum areas). The area has many more challenges, which include a poor and inadequate transportation system, environmental pollution, poor community and social services (93).

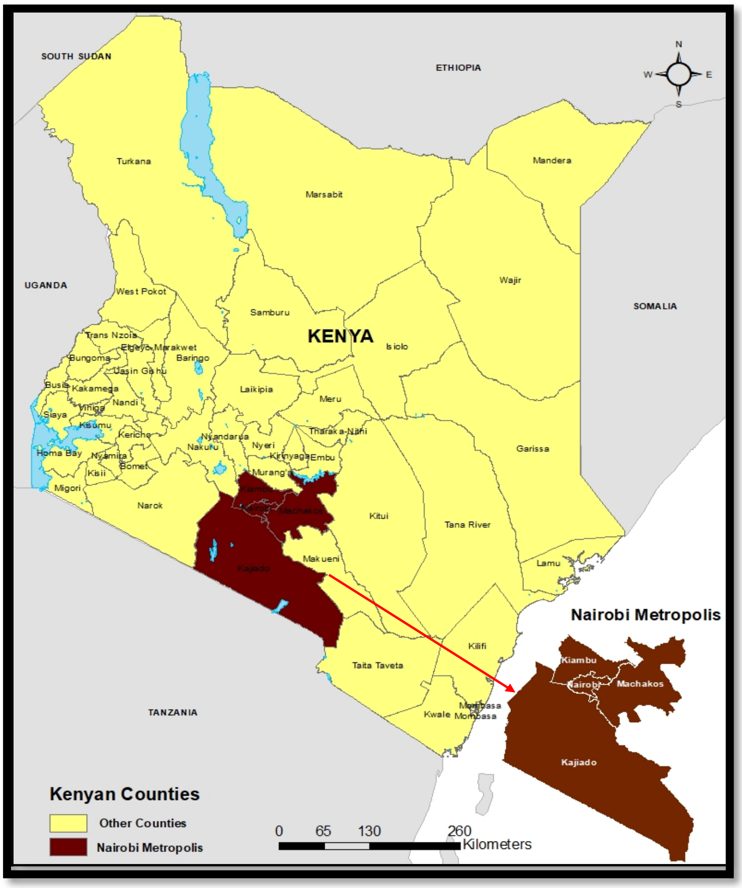

Figure 2. Map of Kenya showing the counties comprising Nairobi Metropolis

Participating health facilities were selected from a list of hospitals from the Kenya COVID-19 line-list and those offering COVID-19 treatment services as listed by the Ministry of Health.

Number of facilities offering isolation services:

Nairobi County- 14

Kiambu County- 5

Kajiado County- 8

Machakos County- 4

3.2 Study population

The study population consisted of confirmed COVID-19 patients of all ages who were severely ill and admitted to different health facilities within Nairobi Metropolis. These were patients admitted between March 2020 and December 2020.

3.3 Study design

The study was a retrospective cross-sectional study of hospitalized severe COVID-19 patients from selected hospitals in Nairobi Metropolis. The study used data from inpatient (patient files) hospital records, seeking to compare both exposures and outcomes for survivors and non-survivors of severe COVID-19 disease.

3.4 Eligibility Criteria

3.4.1Inclusion Criteria

- Laboratory-confirmed SARS-CoV-2 infection using RT-PCR.
- Classification as having severe illness according to WHO guidelines (e.g., oxygen saturation < 90%, respiratory rate > 30 breaths/min, or signs of severe respiratory distress).
- Complete medical records including outcome data (discharge or death).

3.4.2 Exclusion Criteria

- Incomplete or missing medical records.
- Patients referred from other institutions without full documentation.

3.5 Sample size determination

In retrospective cross-sectional studies, especially when comparing two independent groups (e.g., survivors vs. non-survivors), the sample size is typically calculated using the two-proportion comparison formula. In retrospective studies, although researchers often use all available data, formal sample size calculations are important when selecting subgroups, limiting scope, or justifying statistical power (Setia, 2016). This formula determines the number of subjects required in each group to detect a statistically significant difference between two proportions with desired confidence and power levels. The figures in the assumptions below were based on the Ombajo et al. study (Ombajo, 2021). The exposure of interest used was the presence of underlying disease, and the outcome of interest was death (non-survival).

Although retrospective cross-sectional studies often use all available data, sample size can be calculated to ensure sufficient power to detect meaningful differences, especially when selecting records.

Formula for Sample Size (Comparing Two Proportions)

In this study, we were comparing the proportion of exposures (e.g., comorbidities) in survivors and non-survivors, using: (Charan, 2013; Pourhoseingholi, 2013)

$$n = \frac{(Z_{1-\alpha/2} + Z_{1-\beta})^2 \cdot [P_1(1 - P_1) + P_2(1 - P_2)]}{(P_1 - P_2)^2}$$

Where:

- n = minimum sample size per group
- $Z1\_\alpha/2$ = Z-value for the desired confidence level (1.96 for 95%)
- $Z1-\beta$ = Z-value for desired power (0.84 for 80% power)
- P1 = expected proportion in group 1 (survivors)

- $P2$ = expected proportion in group 2 (non-survivors)
- $P1-P2$ = minimum effect size to detect

Calculation

Previous data suggest 39% of survivors and 68% of non-survivors have comorbidity:

- $P1=0.39$, $P2=0.68$
- $\alpha=0.05 \rightarrow Z_{1-\alpha/2}=1.96$
- $\beta=0.20$ (80% power) $\rightarrow Z_{1-\beta}=0.84$

n = 94

Thus, at least 94 patients per group (i.e., survivors and non-survivors) were required. We used 150 in each group (total 300), exceeding 94, providing robust power.

3.6 Sampling procedure

The selection ensured representation for both public and private health facilities. This multi-center selection was guided by county case-loads determined from the national line-list for COVID-19. Counties with low case-load were represented by only one facility, i.e., the facility contributing the highest number of cases to the total county COVID-19 cases by the end of 2020. Counties with high case-loads were represented by more than one facility, depending on the number of cases reported from the county as of 31st December 2020. The study utilized four centers from Nairobi County (2 public and 2 private health facilities), and one from each of the other counties (all public). Below is a list of health facilities offering COVID-19 isolation services by county from which centers were selected:

Nairobi County- Meridian Hospital, Belleview South Hospital, Metropolitan Hospital, MP-Shah hospital, Avenue Hospital Nairobi, Nairobi Hospital, Kenyatta National Hospital, Mbagathi hospital, and Aga Khan University Hospital**.**

Machakos County- Machakos Level 5 hospital, Kangundo level 4 hospital, and Kinanie Health centre**.**

Kajiado County- Kitengela sub-county hospital, Kajiado Referral hospital, Loitokitok sub-county hospital, and Ngong sub-county hospital**.**

Kiambu County- Kenyatta University Teaching Referral and Research Hospital, Thika Level 5 Hospital, Kiambu hospital, and COVID-19 Isolation center Limuru.

The selected health facilities by county from which data was collected were:

Nairobi County- Kenyatta National Hospital, Mbagathi, Avenue, and M.P Shah hospital

Kajiado County- Kajiado County Referral hospital

Machakos County-Machakos County referral (level 5) hospital

Kiambu County- Thika level 5 referral hospital

Data was abstracted without considering whether a case met the criteria for severe COVID-19 disease. Out of the pool of patient abstracted data, final study participants were selected by having met the severe COVID-19 case definition. Patients with laboratory-confirmed COVID-19 test (RT-PCR), and meeting any of the criteria as described by Peng Xie, Wanyu Ma et al., in a study on 'Severe COVID-19: A review of recent progress with a look toward the future (6) and World Health Organization (WHO) (19) were selected. These criteria included any of the following: respiratory rate (RR) of >30 breaths per minute (BpM), measured oxygen concentration of <94% (SPO2), oxygenation index (PaO2/FiO2) ≤300 mmHg (1 mmHg = 0.133 kPa); lung imaging tests showing significant progression (>50%) in lesions in 24–48 hours; age >50 years and Neutrophil-Lymphocyte Ratio (NLR) ≥3.13; respiratory failure and need for mechanical ventilation (non-invasive or invasive ventilator); shock; and Comorbid failure in other organs and need for ICU monitoring and treatment.

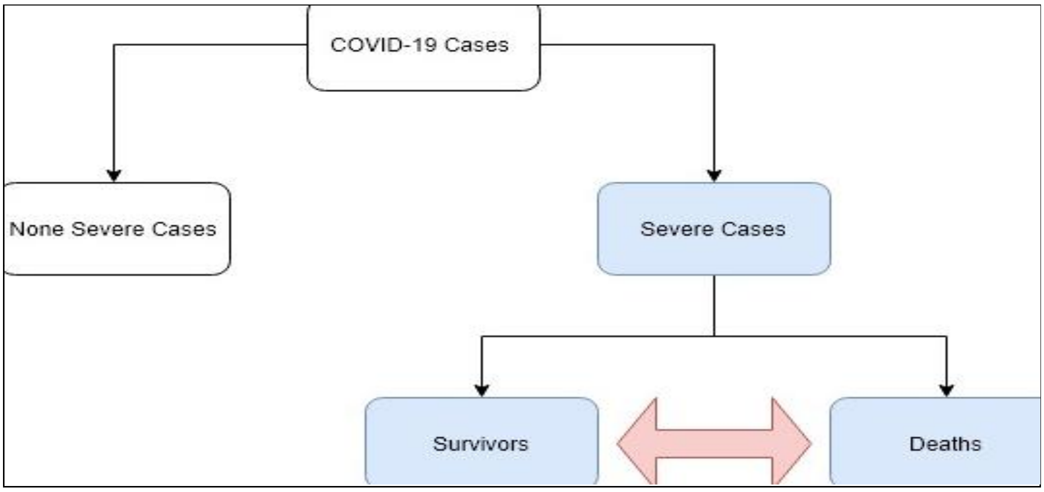

Figure 3. sampling framework for COVID-19 patients in Nairobi Metropolis, March 2020 to Dec 2020

The 300 sample size was arrived at through simple random sampling from the pool of abstracted patient records from across the 7 health facilities. The pool of abstracted patient records from across the 7 health facilities was of patients who had all met the case definition (criteria) for a severe COVID-19 disease. The selected severe COVID-19 patients were put into a separate excel sheet and then divided into two groups: survivors and non-survivors. The two groups of case patients were put into two separate excel sheets to select the final sample size for survivors and non-survivors (both groups- survivors and non-survivors- therefore must have had more than the required entries of 150 case patients each). Both lists were numbered then the excel function of ‘randbetween’ was used to select random patient records to meet the 150 records for each category.

A total of 818 inpatient records were abstracted from seven health facilities in Nairobi Metropolis (Nairobi, Kiambu, Kajiado, and Machakos counties). Out of these, 500

(61%) met the case definition of severe COVID-19. Of the 500 severe cases, 153 (30.6%) were non-survivors. Three (3) of the 153 non-survivors missed vital clinical records and were removed from the analysis. The remaining 150 non-survivors were matched with 150 survivors selected randomly from 347 (69.3%) survivors. **Error! Reference source not found.**.

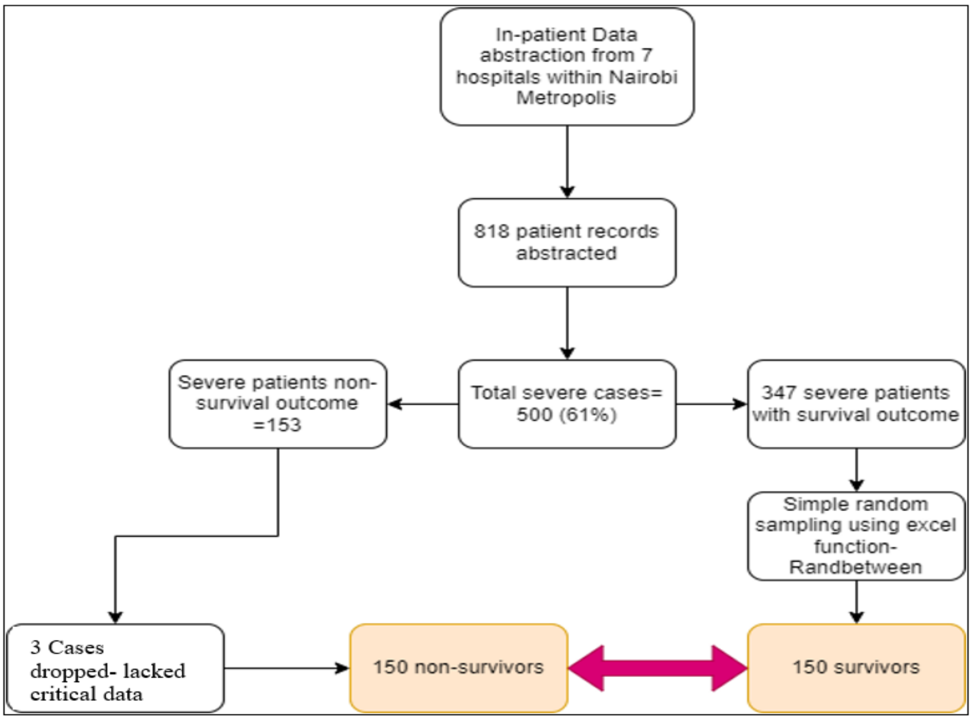

Figure 4. Data abstraction flow of severe COVID-19 disease, from selected hospitals in Nairobi Metropolis, March 2020 to December 2020

3.7 Data collection

Data was collected for the period from 13th March 2020, when the first case was reported in Kenya to 31st December 2020. This was purposely aimed at covering the first two COVID-19 patient surges in the country from the onset of the outbreak. All reporting health facilities were listed by the investigator using the national COVID-19 line-list. Health facilities offering COVID-19 isolation services were then identified from the isolation information of this data. Severe COVID-19 cases were identified after the abstraction of health facility records with the assistance of the COVID-19 focal persons in these health facilities. Data collection clerks were identified from every health facility, trained in the data collection, and then data collection was conducted for six days. Data were extracted using an Excel data collection tool and pre-tested through a mortality survey done by the investigator in mid-2020, both in Nairobi and Mombasa County.

An Excel data extraction tool was used to extract data from hospital records (inpatient files). The data extracted ranged from identification information, presenting signs and symptoms, laboratory and radiological findings during hospitalization, and, where possible, case management.

Variables

Dependent Variable:

- Mortality (died vs. survived)

Independent Variables:

- Socio-demographics: age, sex, residence, occupation
- Clinical characteristics: vital signs, presenting symptoms
- Comorbidities: hypertension, diabetes, HIV, cardiovascular disease
- Laboratory values: white blood cell count, D-dimer, CRP, liver function tests
- Radiological findings: presence of bilateral infiltrates on chest x-ray
- Treatment interventions: oxygen therapy, ICU admission, medications administered

3.8 Data analysis plan

Data were entered into Microsoft Excel and analyzed using R version 4.3.1. Descriptive statistics were used to summarize categorical variables (frequencies, percentages) and continuous variables (means, medians, standard deviations).

Bivariate analysis using Chi-square tests and t-tests identified variables significantly associated with mortality. Logistic regression was performed to determine adjusted odds ratios (AOR) and 95% confidence intervals (CI) for predictors of death. A p-value < 0.05 was considered statistically significant.

3.9 Ethical considerations

IREC approval from Moi University was sought to conduct this study (Appendix 1). A copy of the IREC approval and a letter from the Ministry of Health through K-FELTP was used to access records in selected health facilities within Nairobi Metropolis. Approval was also sought from county directors of health in Machakos, Kajiado, and Kiambu counties. Further approval was sought from Kenyatta National Hospital-University of Nairobi (KNH-UoN) Ethics Review Board (ERC) (Appendix 2) and the management of private hospitals in Nairobi County. NACOSTI approval was obtained before commencing data collection (Appendix 3). The data did not carry identifiable information that could be linked to any patient. However, unique identifiers were used for the line-listed cases, and all the data collection sheets were password protected

3.10 Limitations of the study

The study had some limitations. The study was a retrospective records review and not all records were perfectly filled. There were missing data on different variables from patients' files. Since the COVID-19 pandemic was still active and there was no clear clinical management guidelines, there were a lot of divergent treatment methods. Different hospitals had different procedures and services available for patients with COVID-19. Some crucial services to these patients were available in one hospital and not in another, e.g., ICU services. We turned this disparity into an opportunity to compare how the availability or lack of services contributed to different outcomes. The study was not able to include all the COVID-19 isolation facilities within Nairobi Metropolis due to limited finances and capacity to carry out a review of such scale.

The best approach for this study would have been a prospective cohort study. Due to the resources required for such kind of a study, and limited time, we could not undertake such and therefore opted for a chart review. A prospective cohort would allow the researchers to monitor patient changes and clinical progression, prescribe standard care for all patients, and monitor outcomes. The researchers opted for a retrospective cross-sectional records review, which health authorities can use to inform the need for further study. The novel virus involved a lot of global changes from normal operations and was initially associated with a lot of stigmas. This would equally make it difficult to institute a prospective cohort study.

CHAPTER FOUR

4.0 Results

Out of a total of 818 inpatient records abstracted, 500 (61%) met the case definition for severe COVID-19. The analysis included 300 patients, as demonstrated in the methodology. Most of the patients were from Nairobi County, mainly from Kenyatta National Hospital. The distribution of patients by hospital was as follows:

Avenue hospital- 31(10.4%), Kajiado County Referral- 8(2.7%), Kenyatta National Hospital- 81(27.0%), Kenyatta University Teaching Referral- 14(4.5%), M.P shah hospital – 28(9.5%), Machakos Level 5- 58 (19.4%), and Thika Level 5- 80(26.6%).

4.1 Socio-demographics and Comorbidities of severely ill COVID-19 patients:

4.1.1Socio-demographics Characteristics

The mean age for the 300 severe cases was 53.29 years (±17.7 SD), with the age-group 51–110 years contributing 167 (55.7%) patients. Of the age group 51–110 years, 99 (59.3%) were non-survivors. The mean age for non-survivors was 58.15 years (±17.6 SD), while that for survivors was 48.41 years (±16.3 SD). Males constituted 199 (66.8%) of the severe COVID-19 cases, of whom 102 (51.3%) were non-survivors. **Table 1**.

Table 1. Bivariate relationships between demographic factors with disease outcome of severe COVID-19 patients admitted in hospitals within Nairobi Metropolis, March 2020 to December 2020

Variable	Non-survivors		Crude OR (CI)	P-value
	Yes n (%)	**No n (%)**		
Demographic				
Age groups				
(Years)	99 (66.0)	68 (45.3)	3.0(1.51–5.99)	0.002*
51-110	36 (24.0)	51 (34.0)	1.4(0.68–3.08)	0.324
36-50	15 (10.0)	31 (20.7)	1	1
0-35				
Gender				
Male	102 (68.9)	97 (64.7)	1.2(0.74–1.96)	0.436
Female	46 (31.1)	53 (35.3)	Ref.	1

*Patient factors with p-value ≤0.2 and hence considered for multivariate analysis

Demographic and clinical factors with a p-value less than 0.1 (in association with the outcome) at the bivariate level included the age group of 51 to 110 years, difficulty in breathing, ageusia, and cough. Patients aged 51 to 110 years were 3.0 times more likely to die of severe COVID-19.

4.2 Comorbidities

Fifty-seven percent of all patients, 173 (57.7), had an underlying condition (comorbidity). Of the patients with underlying conditions, 105, 60.7% were non-survivors. Patients with one underlying condition were 114 (38%), while 58 (19.3%) had two underlying conditions. Of those with one underlying conditions, 42 (54.4%) were non-survivors. Of the fifty-eight, 19.3% patients with two or more underlying conditions, 62, 72.4% were non-survivors. Patients with diabetes were 88 (29.3%), while those with hypertension were 85 (28.3%). Of those with diabetes and hypertension, 50 (56.8%) and 56 (65.9%), respectively, were non-survivors, **Table 2.**

Table 2:Bivariate relationships between comorbidity and clinical factors with disease outcome of severe COVID-19 patients admitted in hospitals within Nairobi Metropolis, March 2020 to December 2020

Variable	Non-survivors		Crude OR (CI)	P-value
	Yes	**No**		
Comorbidities				
Presence of comorbidity				
Yes	105 (70.0)	68 (45.3)	2.8(1.75–4.52)	0.000*
No	45 (30.0)	82 (54.7)	Ref.	1
Number of comorbidities				
≥2	42 (28.0)	16 (10.7)	2.1(1.26–3.56)	0.004*
1	62 (41.3)	52 (34.7)	4.6(2.37–9.23)	0.000*
None	46 (30.7)	82 (54.7)	Ref.	1
Hypertension				
Yes	56 (37.3)	29 (19.3)	2.4(1.47–4.19)	0.001*
No	94 (62.7)	121 (80.7)	Ref.	1
Diabetes				
Yes	50 (33.3)	38 (25.3)	1.4(0.89–2.431)	0.129*
No	100 (66.7)	112 (74.7)	Ref.	1
Immunocompromised/HIV				
Yes	10 (6.7)	6 (4.0)	1.7(0.60–4.84)	0.309
No	140 (93.3)	144 (96.0)	Ref.	1
Chronic neurological disease				

Yes	4 (2.7)	1 (0.7)	4.1(0.45–36.95)	0.211
No	146 (97.3)	149 (99.3)	Ref.	1
Chronic lung disease				
Yes	9 (6.0)	1 (0.7)	9.5(1.18–96.03)	0.034*
No	141 (94.0)	149 (99.3)	Ref.	1
Clinical signs				
SPO2 at admission	(n =120)			
<94	**	79 (55.2)	1.5(0.94–2.57)	0.081*
≥94	79 (65.8)	64 (44.8)	Ref.	
	41 (34.2)			
Temperature at admission	(n =105)			
≥38.0°C	**	9 (7.9)	1.3(0.53–3.40)	0.522
<38.0°C	11 (10.5)	104 (92.1)	Ref.	1
	94 (89.5)			
Status at admission				
Severe	140 (93.3)	63 (42.0)	19.3(9.42–	0.000*
Stable	10 (6.7)	87 (58.0)	39.67)	1
			Ref.	

*Patient factors with p-value ≤0.2 and hence considered for multivariate analysis
**Some variables had missing data, and so n was not 300

Comorbidity and clinical factors associated with the outcome of death included: the presence of comorbidity, those with one or more comorbidities, hypertension, diabetes, chronic lung disease, SPO2 less than 94% at admission, and being classified as severely ill at admission. The odds of death among patients with comorbidity were 2.8 times higher than among those without. This odd was 46 times in those with one comorbidity and 2.1 times higher in those with more than one comorbidity. The odds of death among hypertensive patients were 2.4 times higher than those without hypertension; diabetic patients were 1.4 times higher. Patients with chronic lung disease and those with less than 94% SPO2 at admission had 9.5 and 1.5 odds of death, respectively. The odds of death among patients classified as severely ill at admission were 19 times higher than those stable at admission.

4.3 Clinical, laboratory, and radiological characteristics and outcomes:

4.3.1 Clinical characteristics and outcomes

Sixty-four percent of the 300 patients, 193 (64.3%) presented with difficulty in breathing (DIB), while 191 (63.7%) had a cough at admission. Non-survivors with difficulty in breathing were 111, 57.5% while on the contrary 68, 63.5% of survivors did not experience difficulty in breathing. Fever was in 100, 33.3% of the patients, with 105, 52.5% non-survivors manifesting no fever. Cough was reported in 191, 63.7% of the patients, 105, 55% of survivors reported to have cough. Of the non-survivors, 64, 58.7% did not have cough. Going by the measure temperature, 198, 90.8% had a temperature below 37.9^{o}C at admission. During isolation, 211, 90.9% patients had a Peripheral Oxygen saturation (SPO2) of less than 94%. Peripheral Oxygen saturation of survivors below 94% was 64, 60.1%, and 122, 57.8% during admission and isolation respectively. The median number of days from onset of symptoms to seeking health care services was four days (interquartile range of 37 days). For the non-survivors, the median was three days with an interquartile range of 31 days.

Patients presenting with difficulty in breathing were 2.3 times more likely to die than those without. **Table 3**.

Table 3. Bivariate relationships between presenting signs and symptoms with disease outcome of severe COVID-19 patients admitted in hospitals within Nairobi Metropolis, March 2020 to December 2020

Symptoms				
Fever				
Yes	45 (30.0)	55 (36.7)	0.7(0.45–1.19)	0.221
No	105 (70.0)	95 (63.3)	Ref.	1
Difficulty				
breathing	111 (74.0)	82 (54.7)	2.3(1.45–3.83)	0.001*
Yes	39 (26.0)	68 (45.3)	Ref.	1
No				
Anosmia				
Yes	3 (2.0)	5 (3.3)	0.6(0.13–2.52)	0.478
No	147 (98.0)	145 (96.7)	Ref.	1
Ageusia				
Yes	4 (2.7)	9 (6.0)	0.4(0.12–1.42)	0.167*
No	146 (97.3)	141 (94.0)	Ref.	1
Cough				
Yes	86 (57.3)	105 (70.0)	0.5(0.35–0.92)	0.023*
No	64 (42.7)	45 (30.0)	Ref.	1
Chest pain				
Yes	23 (15.3)	40 (26.7)	0.5(0.28–0.88)	0.017*
No	127 (84.7)	110 (73.3)	Ref.	1

*Patient factors with p-value ≤0.2 and hence considered for multivariate analysis

4.4 Diagnosis and Clinical Management

Patient classification at admission was into stable, severe, and critical. Those severely and critically ill were combined as one group, termed 'Severe' in this study. Patients with severe illness at admission were 203 (67.7%). Of these patients, 140 (70%) were non-survivors. Patients diagnosed with other forms of pneumonia, other than COVID-19, in the course of isolation were 92(30.7%). Patients that developed acute respiratory distress syndrome (ARDS) were 78 (26%), while 21 (7%) went into cardiac failure. Non-survivors of those with other forms of pneumonia were 59, 64.1%. ARDS non survivors were 61, 78.2% whiles cardiac failure non survivors were 17, 8%. Non-survivors among those with different other clinical complications were as follows: sepsis 13 (100%), thrombosis 5 (100%), renal failure 7 (100%), etc. table 3.

Upon admission, 85 (28.3%) of the patients were put on oxygen treatment in the course of isolation, with 58 (19.3%) benefitting from mechanical ventilation and 11 (3.7%) from ICU services. Of the 127, 71.7% patients who did not benefit from oxygen treatment, 109, 86.5% were non survivors. Patients' median hospital stay (admission to the outcome) was six days (interquartile range- 214 days). For the non-survivors, this period was four days with an interquartile range of 127 days; see **Table 4** below.

Table 4. Bivariate analysis of clinical factors associated with COVID-19 death among severe COVID-19 patients admitted in selected hospitals in Nairobi Metropolis, March 2020 to December 2020

Variable	Non-survivors		Crude OR (CI)	P-value
	Yes n(%)	**No n(%)**		
Diagnosis and management				
ARDS				
Yes	61 (40.7)	17 (11.3)	5.3(2.94-9.778)	<0.001*
No	89 (59.3)	133 (88.7)	Ref.	1
Cardiac failure				
Yes	17 (11.3)	4(2.7)	4.6(1.531-14.216)	0.007*
No	133 (88.7)	146 (97.3)	Ref.	1
Pneumonia				
Yes	59 (39.3)	33 (22.0)	2.3(1.385-3.814)	0.001*
No	91 (60.7)	117 (78.0)	Ref.	1
Treatment with Oxygen				
No	109 (86.5)	17 (27.9)	6.8(3.538-13.37)	<0.001*
Yes	41 (13.5)	44 (72.1)	Ref.	1
Mechanical ventilation				
Yes	29 (19.3)	29 (19.3)	1.3(0.563-1.773)	1.000
No	121 (80.7)	121 (80.7)	Ref.	1
ICU Admission				
Yes	9 (6.0)	2 (2.3)	4.7(1.003-22.24)	0.050*
No	141 (94.0)	148 (98.7)	Ref.	1

*Patient factors with p-value ≤0.2 and hence considered for multivariate analysis

Diagnosis and management factors with higher odds of death included: acute respiratory distress syndrome (ARDS), cardiac failure, pneumonia, oxygen administration, and ICU admission. The odds of death among severe COVID-19 patients was 5.3 times higher among those who developed ARDS than those who did not. Cardiac failure patients had 4.6 odds of death compared to those without cardiac failure. Patients diagnosed with underlying bacterial pneumonia were 2.3 times more likely to die than those without. The odds of death was 6.8 times higher among those who did not receive oxygen than those who received it.

Distribution of comorbidities by outcome were as shown in **Figure 5.**

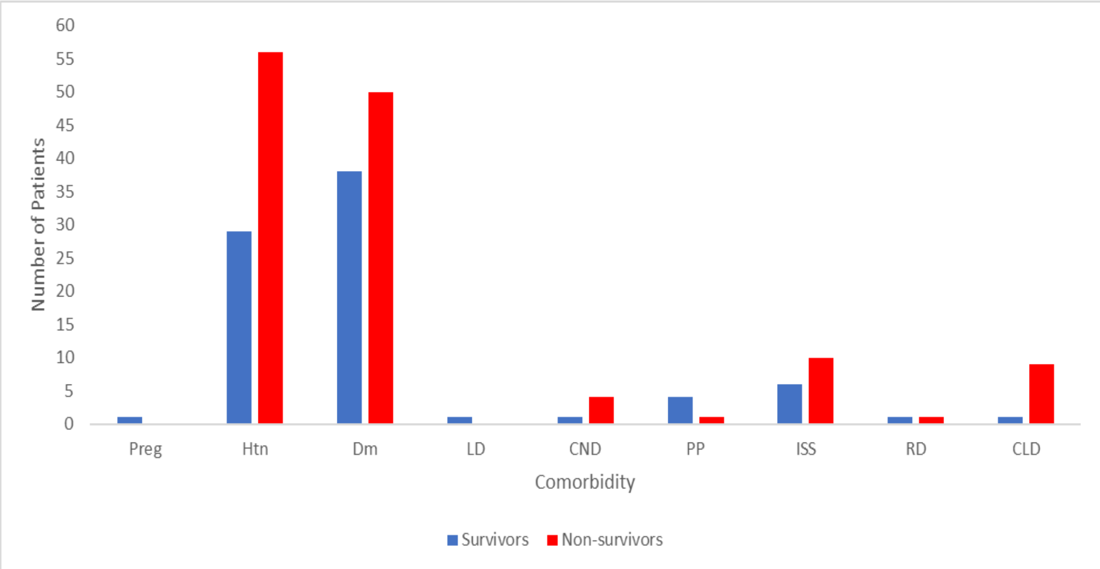

Figure 5. Distribution of comorbidities by outcome for severe COVID-19 patients admitted in selected hospitals, Nairobi metropolis, March to December 2020
*Preg- pregnancy, Htn- hypertension, Dm- diabetes, LD- liver disease, CND- chronic neurological disease, PP- post-partum, ISS- immunodeficiency, RD- renal disease, CLD- chronic lung disease

4.5 Laboratory and radiological findings

Data on the laboratory variables were abstracted for tests done at admission and the highest recorded readings during isolation.

4.5.1 Leucocytes and Liver Function Tests

Patients with elevated leucocytes during isolation were 40 (42.6%), with 30 (75%) of them being non-survivors. Elevated leucocytes at admission were in 61, 38.4% of the patients 42, 68.9% being non survivors. Low hemoglobin levels (below 11.9 g/dl) recorded during isolation for 40.9% patients compared to 30.5% at admission. Of these patients with low hemoglobin at admission and during isolation, 31 (81.6%) and 34

(73.9%) were non-survivors, respectively. Looking at the Liver Function Tests (LFTs), patients with elevated ALT levels were 36 (63.2%) during isolation, 48 (52.7%) at admission, with 19 (52.8%) and 31 (64.6%) being non-survivors, respectively. Similarly, this was replicated in almost all the laboratory variables.

Looking across all the laboratory variables, patients had a higher percentage of raised laboratory readings during isolation than at admission. One such example is the proportion of **Table 5**.

Table 5: Laboratory and radiological findings of severe COVID-19 patients admitted in selected hospitals within Nairobi Metropolis, March 2020 to December 2020

Variable	Number (%)	Non-survivors	Survivors
		Number (%)	**Number (%)**
WBC and Hb			
Leucocytes at admission			
≤4.00	11 (6.9)	3 (27.3)	8 (82.7)
4.01–11.00	87 (54.7)	41 (47.1)	46 (52.9)
≥11.01	61 (38.4)	42 (68.9)	19 (31.1)
Leucocytes in Isolation	(n =94) **		
≤4.00	10 (10.6)	3 (300)	7 (70.0)
4.01–11.00	44 (46.8)	24 (54.5)	20 (45.5)
≥11.01	40 (42.6)	30 (75.0)	10 (25.0)
Hb at admission			
≤11.9	46 (30.5)	34 (73.9)	12 (26.1)
≥12.0	105 (69.5)	46 (43.8)	59 (56.2)
Hb in isolation	(n =93) **		
≤11.9	38 (40.9)	31 (81.6)	7 (18.4)
≥12.0	55 (59.1)	22 (40.0)	33 (60.0)
Liver function test			
ALT at admission	(n =91) **		
≤40.00	48 (52.7)	31 (64.6)	17 (35.4)
≥40.01	43 (47.3)	21 (48.8)	22 (51.2)
ALT in isolation	(n =57) **		
≤40.00	21 (36.8)	16 (76.2)	5 (23.8)
≥40.01	36 (63.2)	19 (52.8)	17 (47.2)
AST at admission	(n =91) **		
≤40.00	62 (75.8)	42 (67.7)	20 (32.3)
≥40.01	29 (24.2)	12 (41.4)	17 (58.6)
AST in isolation	(n =57) **		
≤40.00	13 (22.8)	8 (61.5)	5 (38.5)
≥40.01	44 (77.2)	27 (61.4)	17 (38.6)

**Some variables had missing data, and so n was not 300

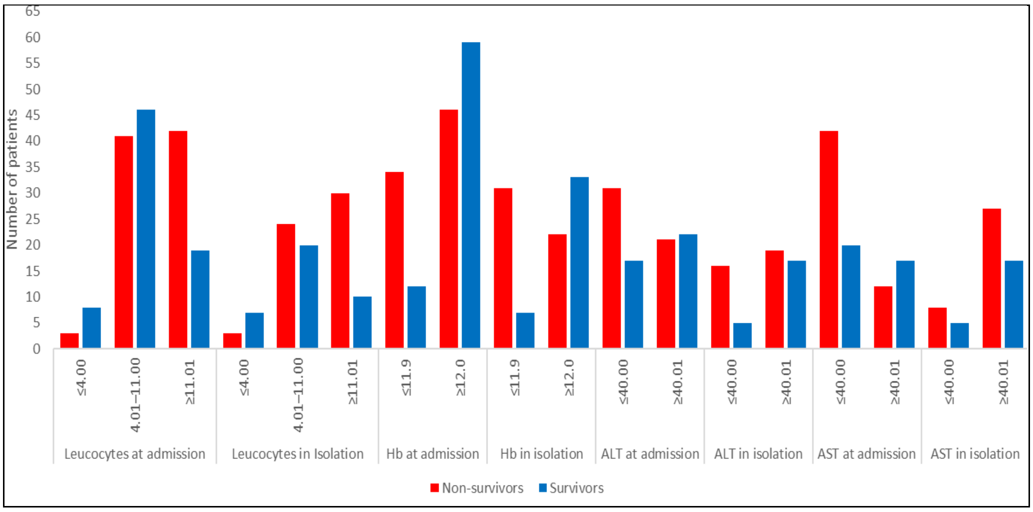

Figure 6:Leucocytes, Hb and LFTs compared at admission and during isolation for survivors and non-survivors, Nairobi Metropolis, March to December 2020

4.5.2 Blood Gases

Blood gases are one of the essential laboratory factors of COVID-19 disease, specifically PO2. Patients with low PO2 in isolation were 47 (65.3%), of whom 38 (80.8%) were non-survivors. **Table 6**.

Table 6. Laboratory and radiological findings of severe COVID-19 patients admitted in hospitals within Nairobi Metropolis, March 2020 to December 2020

Variable	All Cases Number (%)	Non-survivors Number (%)	Survivors Number (%)
Blood Gases			
PO2 at admission	(n =89) **		
≤79.9	36 (40.4)	29 (80.5)	7 (19.5)
≥80.0	53 (59.6)	26 (49.1)	27 (50.9)
PO2 at isolation	(n =72) **		
≤79.9	47 (65.3)	38 (80.8)	9 (19.2)
≥80.0	25 (34.7)	10 (40.0)	15 (60.0)
PCO2 at admission	(n =70) **		
≤34.9	46 (65.7)	30 (65.2)	16 (34.8)
35.0–45.0	14 (20.0)	11 (78.6)	3 (21.4)
≥45.1	10 (14.3)	9 (90.0)	1 (10.0)
PCO2 at isolation	(n =66) **		
≤34.9	32 (47.1)	22 (68.7)	10 (31.3)
35.0–45.0	20 (29.4)	16 (80.0)	4 (20.0)
≥45.1	16 (23.5)	13 (81.2)	3 (18.8)
PH at admission	(n =72) **		
≤7.34	25 (34.7)	24 (96.0)	1 (4.0)
7.35–7.45	31 (43.1)	21 (67.7)	10 (32.3)
≥7.46	16 (22.2)	7 (43.8)	9 (56.2)
PH at isolation	(n =68) **		
≤7.34	26 (38.2)	21 (80.8)	5 (19.2)
7.35–7.45	24 (35.3)	17 (70.8)	7 (29.2)
≥7.46	18 (26.5)	11 (61.1)	7 (38.9)

**Some variables had missing data, and so n was not 300

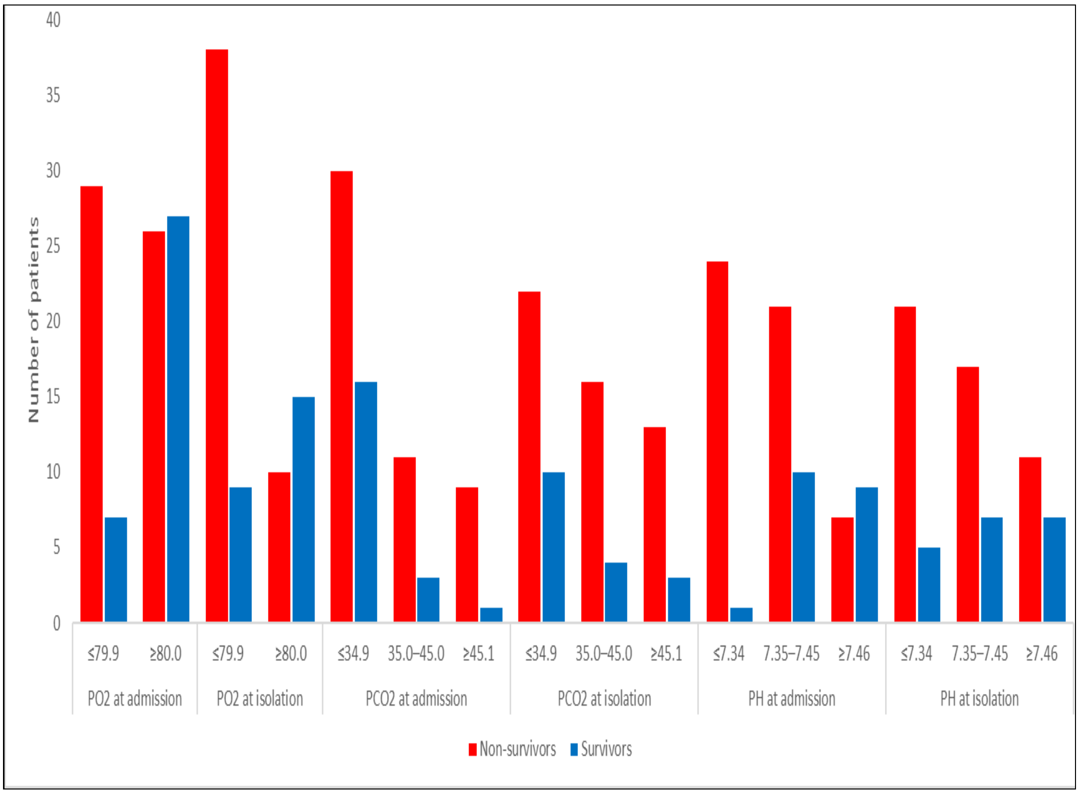

Figure 7. Blood gases compared at admission and during isolation for survivors and non-survivors, Nairobi Metropolis, March to December 2020

4.5.3 Renal Function Tests

Renal function tests are used to monitor the functionality of the renal system. Patients with urine sodium levels below normal at admission were 70 (57%) of 45 (64.3%) were non-survivors. During isolation, 36 (35.6%) patients had sodium levels below normal, 22 (61.1%) were non-survivors. **Table 7**.

Table 7. Laboratory and radiological findings of severe COVID-19 patients admitted in hospitals within Nairobi Metropolis, March 2020 to December 2020

Variables	**All Cases Number (%)**	**Non-survivors Number (%)**	**Survivors Number (%)**
Renal function tests			
Sodium at admission	(n =149) **		
≤134.9	70 (47.0)	45 (64.3)	25 (35.7)
135.0–145.0	67 (45.0)	30 (44.8)	37 (55.2)
≥145.1	12 (8.0)	8 (66.7)	4 (33.3)
Sodium at isolation	(n =101) **		
≤134.9	36 (35.6)	22 (61.1)	14 (38.9)
135.0–145.0	52 (51.5)	32 (61.5)	20 (38.5)
≥145.1	13 (12.9)	9 (69.2)	4 (30.8)
Potassium- admission	(n =151) **		
≤3.2	15 (9.9)	6 (40.0)	9 (60.0)
3.3–5.4	124 (82.2)	66 (53.2)	58 (46.8)
≥5.5	12 (7.9)	11 (91.7)	1 (8.3)
Potassium- admission	(n =99) **		
≤3.2	6 (6.1)	4 (66.7)	2 (33.3)
3.3–5.4	82 (82.8)	47 (57.3)	35 (42.7)
≥5.5	11 (11.1)	10 (90.9)	1 (9.1)
Urea at admission	(n =141) **		
≤1.99	4 (2.8)	1 (25.0)	3 (75.0)
2.00–8.00	89 (63.2)	41 (46.1)	48 (53.9)
≥8.01	48 (34.0)	38 (79.2)	10 (20.8)
Urea at isolation	(n =95) **		
≤1.99	1 (1.1)	0 (0.0)	1 (100.0)
2.00–8.00	55 (57.9)	28 (50.9)	27 (49.1)
≥8.01	39 (41.0)	31 (79.5)	8 (20.5)
Creatinine- admission	(n =144) **		
≤59.99	11 (7.6)	7 (63.6)	4 (236.4)
60.00–130.00	89 (61.8)	40 (44.9)	49 (55.1)
≥130.01	44 (30.6)	35 (79.5)	9 (20.5)
Creatinine at isolation	(n =97) **		
≤59.99	8 (8.2)	8 (100.0)	0 (0.0)
60.00–130.00	57 (58.8)	26 (45.6)	31 (54.4)
≥130.01	32 (33.0)	27 (84.4)	5 (15.6)

**Some variables had missing data, and so n was not 300

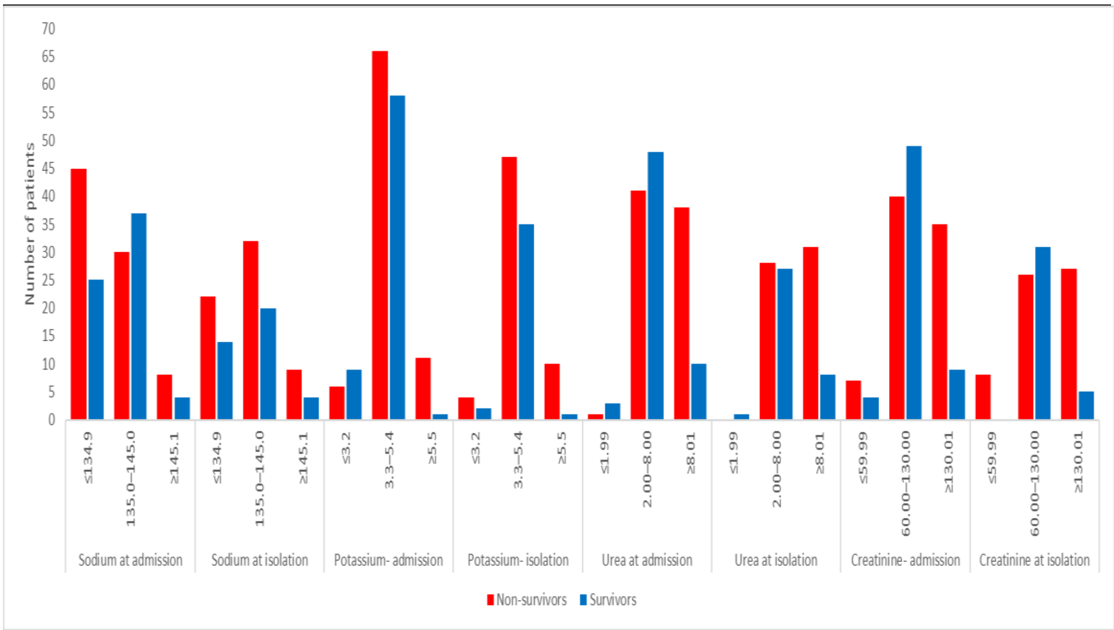

Figure 8. RFTs compared at admission and during isolation for survivors and non-survivors, Nairobi Metropolis, March to December 2020

4.5.4 X-rays and Chest CT-Scan:

Only 37 (12.3%) of the 300 patients had an X-ray done, of whom 9 (24.3%) were reported to have had features of pneumonia and ground glass opacification. Chest CT-scan had been done for only 17 (5.7%) of the 300 patients. Of the 17 patients with chest CT-scan, 9 (52.9%) had features of pneumonia and ground glass opacification.

4.5.5 Adjusted National Early Warning Score (ANEWS) for COVID-19

Due to a lack of data on variables like level of consciousness, pulse rate, etc., six variables were used to score for ANEWS, which include: age, temperature, SPO2, respiratory rate, comorbidity, and oxygen administration. Patient scores were as in table 6 below. Patients who needed urgent to emergency response were 64%, hence warranting consideration for ICU admission. One shortcoming with this classification from abstracted data is the timings on when the above signs and symptoms occurred in every individual patient.

Table 8. Adjusted National Early Warning Score (ANEWS) for COVID-19

ANEW Score	Number of patients	Clinical risk	Frequency of monitoring	Response
0–4	108	Low	Minimum 4–6 hours	Ward based
≥3 in 1	(36%)	Low	Minimum 1 hourly	Urgent ward-based
parameter	211	medium	Minimum 1 hourly	response
5–7	(70%)	Medium		Key threshold for urgent
	108		Continuous	response
≥7	(36%)	High		Urgent or emergency
				response
	84			
	(28%)			

4.5.6 Predictors of mortality:

Hypertension, acute respiratory distress syndrome (ARDS), patients who did not receive oxygen during isolation, and patients with severe disease at admission were factors associated with mortality. Hypertension (OR-3.5, 95% CI- 1.34–9.45, p-value- 0.011); ARDS (OR- 8.9, 95% CI- 3.05–26.14, p-value- <0.001); severe disease at admission (OR- 18.7, 95% CI- 5.24–67.15, p-value <0.001); and failure to receive oxygen treatment (OR- 17.5, 95% CI- 5.54–55.32, p-value <0.001).

Table 9.

Table 9. Multivariate analysis of factors associated with COVID-19 death among severe COVID-19 patients admitted in selected hospitals in Nairobi Metropolis, March 2020 to December 2020

Variables	Non-survivors		Adjusted OR (CI)	P-value
	Yes	**No**		
Hypertension				
Yes	56 (37.3)	29 (19.3)	3.5 (1.34-9.45)	0.011
No	94 (62.7)	121 (80.7)		
Treatment with Oxygen				
No	109 (72.7)	17 (27.9)	17.5 (5.54-55.32)	<0.001
Yes	41 (27.3)	44 (72.1)		
ARDS				
Yes	61 (40.7)	17 (11.3)	8.9 (3.05-26.14)	<0.001
No	89 (59.3)	133 (88.7)		
Disease at admission				
Severe	140 (93.3)	63 (42.0)	18.7 (5.24-67.15)	<0.001
Stable	10 (6.7)	87 (58.0)		

CHAPTER FIVE

5.1 Discussion

This study investigated the factors associated with mortality among severely ill COVID-19 patients in Nairobi Metropolis. The findings align with global trends but also highlight context-specific challenges unique to Kenya's urban healthcare landscape. Four primary predictors of mortality were identified: advanced age (>60 years), hypertension, oxygen saturation below 90% at admission, and lack of access to oxygen therapy. These factors emphasize the importance of early diagnosis, aggressive management of comorbidities, and the critical role of health system capacity in mitigating COVID-19 deaths.

5.2 Age and Mortality

Consistent with international literature, older age was strongly associated with mortality. Patients over 60 years had nearly three times the odds of death compared to younger patients. Aging is associated with immunosenescence, increased comorbidities, and decreased physiological reserves (Zhou et al., 2020). In Kenya, the elderly population is less than 5%, but their disproportionate representation among COVID-19 fatalities signals the need for targeted interventions, including prioritized vaccination and early referral pathways for senior citizens.

The prevalence of diabetes and hypertension increased with the advancement in age in a study done by Werner et al. (60) in a Kenyan urban population. The odds of hypertension among people with diabetes was two-fold in the elderly, especially among women. One of the findings of this study was that diabetes and hypertension were common among the elderly, with many having both diabetes and hypertension, and the majority were non-survivors.

5.3 Comorbidities: The Role of Hypertension

Hypertension emerged as a significant predictor of death. This aligns with global data from New York (Richardson et al., 2020) and Italy (Grasselli et al., 2020), where hypertension was prevalent among critically ill patients. In a pooled analysis by Giuseppe Lippi et al. (64), hypertension was 2.5 times associated with both severity of COVID-19 disease and mortality; an observation made only in those more than 60 years of age. Diabetes and hypertension findings could be explained by the disruption of clinical services for such diseases, especially during the initial phase of the pandemic from which these cases were drawn. Diabetes and hypertension are also associated with dysregulation of the immune system(65), making the already naïve immune system to COVID-19 worse.

In the Kenyan setting, poor control of non-communicable diseases (NCDs), limited routine health checks, and inadequate access to antihypertensive medications likely exacerbate this risk. Strengthening primary healthcare and integrating NCD screening into pandemic preparedness frameworks could reduce these indirect COVID-19 complications.

5.4 Clinical Severity at Admission

The presence of oxygen saturation <90% and symptoms such as dyspnea on admission were significantly more common in non-survivors. Hypoxemia reflects advanced disease and is a hallmark of acute respiratory distress syndrome (ARDS). Early identification of patients in respiratory distress through robust triage systems and pulse oximetry can enable timely oxygen supplementation, improving survival rates (WHO, 2020).

This could be partly explained by patients' delays in seeking health care services. Such delays could have been occasioned by the stigma initially associated with the disease. Such delays could mean that patients were presenting to the hospital only when a worsening situation due to illness would force them to do so. The median number of days spent after the onset of symptoms to hospitalization was four days, which is too many considering the accelerated clinical course of COVID-19, especially in those with severe disease. It is, therefore, essential to influence the health-seeking behaviors of the Nairobi Metropolis population. This poor health-seeking behavior could further mean that the much-needed public health education and the creation of awareness about COVID-19 did not attain better results. This lack of effect could be due to myths and misinformation having contributed to the hesitance to seek health care by Nairobi Metropolis residents. Naeem et al. report on how fighting fake news became the new front of fighting the COVID-19 pandemic (Ndugga et al., 2021).

5.5 Oxygen Therapy and Resource Limitations

Lack of oxygen therapy was the most significant independent predictor of death, with patients who did not receive oxygen being over four times more likely to die. This underscores the central role of oxygen as a life-saving intervention in COVID-19 care. In Nairobi and other parts of Kenya, oxygen availability was sporadic during pandemic peaks due to supply chain issues and inadequate hospital infrastructure. The WHO's "Oxygen Access Scale-Up" initiative recommends national investments in oxygen plants, cylinder supply systems, and staff training, particularly in low-resource settings (WHO, 2021).

COVID-19 causes damage to the three important components of oxygen uptake in the lungs: the alveoli, pulmonary, and bronchial arterial supply (McGonagle D et al., 2021). This damage and disruption of function for the above three components results in high chest pain frequency, which was true in this study. This damage is usually demonstrated by the ground grass opacification in a CT scan of the lungs. In this study, very few patients had a CT scan done on them. However, from the available data on CT scan, ground glass opacification was the most common presentation. In a small sample, treatment with oxygen-ozone led to a reduction in inflammatory markers and D-dimer levels in patients with COVID-19 and drastically reduced the need for mechanical ventilation (Hernández A et al., 2020). In a meta-analysis on the use of hyperbaric oxygen therapy, a systematic review of eight (8) different studies showed that, after several sessions of treatment, patients' blood oxygen saturation improved (Oliaei S et al., 2021). This study demonstrates that failure to receive oxygen treatment was associated with mortality, with the odds of death being 17.5 times higher among those who did not receive oxygen compared to those who received it. Though the sample was not large enough, with challenges of missing data, this is a significant finding which if addressed, it would bring a huge difference. We must also point out that, oxygen was one of the golden resources that become hard to come by in the heap of COVID-19 pandemic. Manufacturing plants were stretched to their limit to meet the demand in the market. This study and other publish studies show that if oxygen was available to all patients with saturation below 94%, and especially hyperbaric oxygen or oxygen-ozone would have made a very huge difference in the outcomes of these patients.

5.6 Health System Factors and ICU Care

Although ICU admission did not reach statistical significance in this analysis, the trend suggested a protective effect. This may be confounded by limited ICU bed availability and strict admission criteria. Many severely ill patients in Kenya are managed in general wards due to constrained critical care resources. Strengthening ICU capacity through infrastructure, staffing, and procurement of equipment is essential not only for COVID-19 but also for managing future respiratory pandemics.

What then determined who benefited from this scarce resource at this phase of the pandemic, and thereafter? In a meta-analysis involving seven studies (Vageesh J, 2020), dyspnea (difficulty breathing) was the only symptom significantly associated with ICU admission, with a prevalence odds ratio (POR) of 6.55, 95% confidence interval of 4.28–10.0. In the same study, chronic obstructive pulmonary disease, cardiovascular disease, diabetes, and hypertension were the underlying chronic illnesses associated with ICU admission. Patients with chronic obstructive pulmonary disease were 17.8 times more likely to be admitted to the ICU, while those with cardiovascular disease were 4.44 times, hypertension 3.65 times, and diabetes 2.7 times more likely.

5.7 Comparison with Other Studies

The study’s findings corroborate reports from Wuhan (Zhou et al., 2020), New York (Richardson et al., 2020), and South Africa (Jassat et al., 2021), reinforcing the universal nature of certain risk factors. However, the unique challenges of resource limitations, fragmented referral systems, and late presentation observed in Kenya provide critical insight into mortality drivers in LMICs.

5.8 Limitations

This study had several limitations. Being retrospective, it relied on existing medical records, which sometimes lacked completeness. It was also limited to three hospitals, potentially affecting generalizability. Additionally, socio-economic status and time-to-presentation were not captured but may significantly influence outcomes.

5.8.1 Implications for Practice and Policy

The findings underscore the need for:

- Early risk stratification of patients at the point of care.
- Prioritizing oxygen availability in all hospitals.
- Incorporating NCD care in pandemic response.
- Enhancing surveillance and data systems for real-time decision-making.
- Establishing standard protocols for critical care referral and ICU admission.

5.8.2 Future Research

Further studies should explore long-term outcomes among survivors, incorporate qualitative assessments of healthcare access, and examine the cost-effectiveness of specific interventions like portable oxygen systems in community care. Multi-center studies involving both rural and urban populations would also offer a more comprehensive national perspective.

In summary, mortality among severely ill COVID-19 patients in Nairobi is driven by a combination of clinical severity, pre-existing conditions, and systemic healthcare limitations. Interventions focused on timely care, resource allocation, and integrated disease management are essential to reduce preventable deaths.

CHAPTER SIX

6.0 CONCLUSION, RECOMMENDATION, AND PUBLIC HEALTH IMPACT

6.1 Conclusion

This study sought to identify the factors associated with mortality among severely ill COVID-19 patients admitted in hospitals within Nairobi Metropolis, Kenya. The results highlighted that advanced age, hypertension, hypoxia at admission, and lack of oxygen therapy were independently associated with increased risk of death. These findings are consistent with international evidence, yet they also reflect unique health system challenges within the Kenyan context.

By answering the primary research question and achieving the stated objectives, this study adds value to the body of knowledge on COVID-19 outcomes in sub-Saharan Africa. The insights gained provide an evidence base for clinicians and policymakers to prioritize resource allocation, improve hospital preparedness, and develop interventions targeting high-risk groups.

Ultimately, the study underscores the urgent need for improved access to critical care services, particularly oxygen therapy, and supports efforts to enhance clinical management strategies for COVID-19 and future respiratory pandemics in low-resource urban settings.

6.2 Recommendations

Based on the study findings and identified mortality predictors, the following actionable recommendations are proposed:

1. **Enhance Early Risk Stratification and Triage:**
    - Implement routine screening for oxygen saturation and signs of respiratory distress at all health facility entry points.
    - Prioritize rapid clinical decision-making tools to identify high-risk patients.
2. **Scale Up Oxygen Supply and Infrastructure:**
    - Invest in sustainable oxygen production, storage, and delivery systems in all county and referral hospitals.
    - Establish reliable oxygen logistics and maintenance systems, including partnerships with private suppliers.
3. **Expand ICU and High Dependency Unit (HDU) Capacity:**
    - Increase the number of ICU and HDU beds and ensure appropriate staffing and equipment in public health facilities.
    - Develop decentralized critical care units in sub-county hospitals to ease the burden on tertiary facilities.
4. **Improve Management of Non-Communicable Diseases (NCDs):**
    - Integrate NCD screening and management into routine care, particularly for patients over 40 years.

- Strengthen community health education and medication access for hypertension and diabetes.

5. **Capacity Building for Health Workers:**
    - Train healthcare providers in the management of respiratory failure, use of oxygen delivery systems, and ICU protocols.
    - Provide simulation-based training on emergency response and pandemic preparedness.
6. **Strengthen Surveillance and Health Information Systems:**
    - Enhance data collection and electronic health record systems for real-time monitoring of disease progression and resource use.
    - Support research and data-driven policymaking by creating linkages between hospitals, academia, and the Ministry of Health.
7. **Develop Emergency Preparedness and Response Policies:**
    - Institutionalize pandemic response frameworks that address critical care access, resource allocation, and surge capacity planning.
    - Regularly update protocols based on emerging evidence and lessons from previous outbreaks.

These recommendations are aimed at improving outcomes for severely ill patients and strengthening Kenya’s health system response to future health emergencies.

6.2.1 Public Health Impact

The initial study that preceded this study was part of what informed the interim guidelines on the management of COVID-19 in Kenya. This study was also published in the Journal of Interventional Epidemiology and Public Health (JIEPH) (Charles Mulwa Muendo et al. 2021).

The results of this study were presented at an international conference and the Ministry of Health's internal forums (Muendo, 2023).

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APPENDICES

Appendix 1: Moi University IREC Approval

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471/2/3

MOI UNIVERSITY
COLLEGE OF HEALTH SCIENCES
P.O. BOX 4606
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Tel: 33471/2/3

Reference: IREC/2021/40
Approval Number: 0003885

27th May, 2021

Charles Mulwa Muendo,
Moi University,
School of Public Health,
P.O. Box 4606-30100,
ELDORET-KENYA.

Dear Mr. Muendo,

FACTORS ASSOCIATED WITH MORTALITY AMONG SEVERE CORONAVIRUS DISEASE-2019 PATIENTS, NAIROBI METROPOLIS

This is to inform you that ***MTRH/MU-IREC*** has reviewed and approved your above research proposal. Your application approval number is ***FAN: 0003885.*** The approval period is **27th May, 2021- 26th May, 2022.**

This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, Material Transfer Agreements (MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***MTRH/MU-IREC.***
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 ***MTRH/MU-IREC*** 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 ***MTRH/MU-IREC*** within 72 hours.
v. Clearance for export of biological specimens must be obtained from ***MOH at the recommendation of NACOSTI*** for each batch of shipment.
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 ***MTRH/ MU-IREC.***

Prior to commencing your study; you will be required to obtain a research license from the National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and other relevant clearances from study sites including a written approval from the CEO-MTRH which is mandatory for studies to be undertaken within the jurisdiction of Moi Teaching & Referral Hospital (MTRH) and its satellites sites.

Sincerely,

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
27 MAY 2021
APPROVED
P. O. Box 4606 - 30100 ELDORET

PROF. E. WERE
CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc	CEO	-	MTRH	Dean	-	SOP	Dean	- SOM

Appendix 2: NACOSTI Research License

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Ref No: **425904**

Date of Issue: **02/July/2021**

RESEARCH LICENSE

This is to Certify that Dr.. Charles Mulwa Muendo of Moi University, has been licensed to conduct research in Kajiado, Kiambu, Machakos, Nairobi on the topic: Factors Associated with Mortality among Severe Coronavirus Disease- 2019 Patients, Nairobi Metropolis for the period ending : 02/July/2022.

License No: **NACOSTI/P/21/11467**

425904

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.

Appendix 3: Data Abstraction Tool

Data Collection Tool

To extract data from hospital records, specifically in-patient files, an Excel data extraction tool was employed for streamlined and efficient data retrieval. The data extracted ranged from identification information, presenting signs and symptoms, laboratory and radiological findings during hospitalization, and, where possible, case management. The detailed information abstracted from patient files is as follows:

Identification information

Identification Number

Nationality

Age

Gender

Occupation

County

Sub County

Ward

Village

Facility

Date of onset

Date of admission

Signs and Symptoms (Yes/No)

Fever

Malaise

Cough

Sore throat

Runny 0se

Difficulty In Breathing

Diarrhea

Nausea

Vomiting

Headache

Anosmia

Ageusia

Chest pain

Temperature at admission and the highest record during isolation

Respiratory Rate at admission and the highest record during isolation

Oxygen saturation at admission and the lowest record during isolation

Comorbidities (Yes/No)

Number of comorbidities

Pregnancy

Hypertension

Diabetes Mellitus

Liver disease

Chronic Neuromuscular disease

Post-partum

Immunodeficiency

Renal disease

Chronic lung disease and Others

Laboratory Tests

White Blood Cells (WBC) levels at admission and the highest record during isolation

Hemoglobin level at admission and the lowest record during isolation

Sodium level at admission and the highest record during isolation

Potassium levels at admission and the highest record during isolation

Kidney function tests (Urea and Creatinine)

Liver function tests (ALT and AST)

Blood gases (PO2, PCO2, and PH)

Radiological Results

Chest Xray

Chest Computed Tomography (CT) Scan

Clinical Diagnosis

Status at admission (Mild, or severe, or critical disease)
Oxygen administration
Acute Respiratory Disease
Cardiac failure
Sepsis
Thrombosis
Renal failure
Pneumonia and Others

Clinical treatment

Mechanical Ventilation

Number of days on Mechanical Ventilation

Intensive Care Unit or High Dependency Unit admission

Number of days in ICU/HDU

Outcome

Date of outcome

Appendix 4: Plagiarism Certificate

SR433

ISO 9001:2019 Certified Institution

THESIS WRITING COURSE

PLAGIARISM AWARENESS CERTIFICATE

This certificate is awarded to

CHARLES MULWA MUENDO

FELTP/4172/20

In recognition for passing the University's plagiarism

Awareness test for Thesis **entitled: FACTORS ASSOCIATED WITH MORTALITY AMONG SEVERELY ILL COVID-19 PATIENTS, NAIROBI METROPOLIS** similarity index of 5% and striving to maintain academic integrity.

Word count: 20068

Awarded by

Prof. Anne Syomwene Kisilu

CERM-ESA Project Leader Date: 10/01/2024