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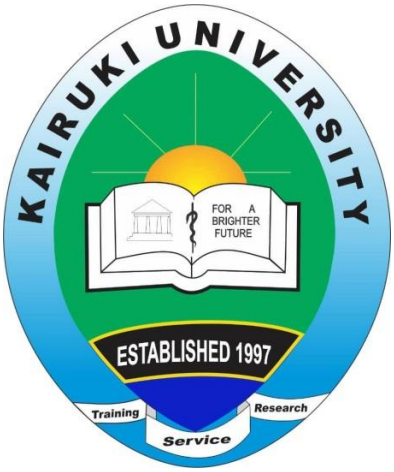

VENTILATOR ASSOCIATED PNEUMONIA AMONG ADULT PATIENTS IN INTENSIVE CARE UNITS AT MUHIMBILI.

By

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CERTIFICATION

The undersigned certifies that he has read and here by recommends for acceptance by Kairuki University a dissertation entitled, "***VENTILATOR ASSOCIATED PNEUMONIA AMONG ADULT PATIENTS IN INTENSIVE CARE UNITS AT MUHIMBILI.***" In partial fulfilment of the requirements for the award of Degree of Masters in Internal Medicine.

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DECLARATION AND COPYRIGHT

Michael Gilya, the author, affirm that this dissertation represents my own original work. It has neither been submitted in part or in full to any other university before, nor will it be submitted to any institution for the purpose of obtaining a similar or any other degree award.

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DEDICATION

I dedicate this dissertation to my loving family, whose unwavering support and encouragement have been my guiding light throughout this journey. Your belief in me has been instrumental in shaping my aspirations and pushing me to strive for excellence.

This endeavor reflects the values you have instilled in me, and I am eternally grateful for your love and sacrifices.

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ABSTRACT

Background: Ventilator-associated pneumonia (VAP) is a serious nosocomial infection affecting patients undergoing mechanical ventilation, especially in intensive care units (ICUs). The increasing prevalence of multidrug-resistant (MDR) organisms complicates management and worsens patient outcomes, particularly in low-resource settings.

Objective: This study aimed to determine the bacteriological profile, antimicrobial resistance patterns, and associated risk factors of VAP among mechanically ventilated patients in three public tertiary hospitals in Dar es salaam, Tanzania.

Methods: A hospital-based cross-sectional study was conducted at Muhimbili (MNH, JKCI, and MOI). ICUs Patients who were mechanically ventilated for ≥48 hours were evaluated for VAP using the Clinical Pulmonary Infection Score (CPIS ≥6). Endotracheal aspirates were cultured, and antimicrobial susceptibility testing (AST) was performed using the Kirby-Bauer disc diffusion method following CLSI guidelines. Data were analyzed using SPSS, and logistic regression was applied to identify factors associated with VAP.

Results: Among 119 patients, 52 (43.7%) were diagnosed with VAP. Among these 52 cases, the predominant bacterial isolates were *Pseudomonas aeruginosa* 15 (28.8%), *E. coli* 10 (19.2%), *Klebsiella pneumoniae* 7 (13.5%), *Acinetobacter spp.* 6 (12%), and *Staphylococcus aureus* 9 (17.3%). Over 69.5% of isolates exhibited multidrug resistance, especially against cephalosporins, fluoroquinolones, and aminoglycosides. Age was identified as an independent predictor of VAP in the adjusted analysis.

Conclusion: This study reveals a high VAP burden and MDR prevalence in Tertiary Hospitals ICUs, highlighting the need for strengthened infection prevention, empirical therapy review, and robust antimicrobial stewardship policies.

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LIST OF ABBREVIATION

AST	Antimicrobial Susceptibility Testing
CFU	Colony forming unit
CLSI	Clinical and Laboratory Standard Institute
CPIS	Clinical Pulmonary Infection Score
ETT	Endotracheal tube
ESBL	Extended-spectrum β-lactamase
FiO_2	Fraction of Inspired Oxygen
HAI	Hospital acquired infection
ICU	Intensive Care Unit
INICC	International nosocomial infection control consortium
JKCI	Jakaya Kikwete Cardiac Institute
LMICs	Low- and middle-income countries
MDR	Multi-drug resistant organisms
MNH	Muhimbili National Hospital
MOI	Muhimbili Orthopaedic Institute
MRSA	Methicillin-resistant Staphylococcus aureus
MV	Mechanical ventilation
NHSN	National health safety network
VAP	Ventilator-associated pneumonia
USA	United state of America
PEEP	Positive End-Expiratory Pressure

OPERATIONAL DEFINITION OF TERMS

Hospital acquired pneumonia

Pneumonia that occurs 48 hours or more post admission and was not present during admission[1].

Ventilator associated pneumonia

a type of hospital-acquired pneumonia that develops 48 hours after the initiation of invasive mechanical ventilation. It is identified using the Modified Clinical Pulmonary Infection Score (CPIS), which assigns points based on key clinical and laboratory parameters: body temperature, white blood cell counts and band forms, the amount and appearance of tracheal secretions, oxygenation status (PaO_2/FiO_2 ratio), chest X-ray findings, and results from endotracheal aspirate cultures. A CPIS $\geq$ 6 typically indicates the presence of VAP[2].

Invasive Mechanical Ventilation

Is a life-support intervention that provides artificial breathing through a ventilator, typically via an endotracheal tube (ETT) or a tracheostomy tube[3].

Primary Diagnosis

This is the main condition or disease that is chiefly responsible for a patient's admission in intensive care units.

Comorbidity

Defined as the presence of one or more additional medical conditions that coexist with the primary diagnosis in the same patient.

Multi-drug resistance bacteria

These are bacteria that are resistant to at least one antibiotic in three (or more) different antibiotic classes.

Muhimbili

This is an area located at Upanga in Ilala District, Dar es Salaam, Tanzania. It is widely recognized as a hub for healthcare and medical education in the country. The area hosts four key national institutions, including three hospitals which serve as the highest-level referral centers in Tanzania, comprise the Muhimbili National Hospital (MNH), Muhimbili Orthopaedic Institute (MOI), and Jakaya Kikwete Cardiac Institute (JKCI). They provide specialized health care services while also serving as teaching and research hospitals through their collaboration with Muhimbili University of Health and Allied Sciences (MUHAS).

CHAPTER ONE

1.0 INTRODUCTION

Ventilator-associated pneumonia (VAP), a type of hospital-acquired pneumonia that develops 48-72 hours after the initiation of invasive mechanical ventilation.[2,4,5]

Different bacteria like pseudomonas aeruginosa, Methicillin-sensitive Staphylococcus aureus, Methicillin-resistant Staphylococcus aureus (MRSA), Acinetobacter species, Escherichia coli, Klebsiella pneumoniae, etc. have reported to cause ventilator associated pneumonia (VAP) in different studies with different predominance.[2,4,6] Patients who develop ventilator associated pneumonia stay in the Intensive Care Unit (ICU) for noticeably longer duration than other patients, and their overall hospital stay, thereby leading to a rise in both hospital expenses and the death rate.[4,7–9]

This study intends to determine prevalence of VAP and antibiotics susceptibility of bacteria isolates linked with ventilator associated pneumonia in ICUs at the Muhimbili.

1.1 Background

1.1.1 Ventilator-associated pneumonia (VAP)

Hospital acquired pneumonia (HAP) is the pulmonary parenchymal infection brought by microorganism found in the hospital environments. Patients admitted to the hospital for more than 48 hours are susceptible to nosocomial pneumonia, which typically takes at least two days to incubate[1]. The nosocomial pneumonia known as ventilator associated pneumonia (VAP) occurs in patients in ICU, 48-72 hours after the initiation of invasive mechanical ventilation.[2,4,5] It makes using artificial ventilation challenging[10], and is the most commonly contracted infection in intensive care units[11–14].

Ventilator associated pneumonia can be classified as early onset if it occurs in less than 4 days and when it develops after 4 days is considered as delayed type of VAP[13,15,16.] The Early onset

VAP is more likely to be brought on by germs that are susceptible to antibiotics, is typically less severe, and has a better prognosis unlike the delayed type which is often caused by resistant bacteria and is associated with poor outcome[17]

A number of risk factors have been found to be substantially linked to the development of ventilator-associated pneumonia (VAP), including re-intubation, emergency intubation, prolonged intubation, impaired level of conscious, tracheostomy, and enteral feeding.[2,15,16,18]

1.1.2 Epidemiology of Ventilator Associated Pneumonia

Ventilator associated pneumonia affect approximately 5-40% of patients receiving mechanical ventilation for more than 48 hours[19] and it may reach up to 76% in some ICU settings[20]. The observed large variation influenced by nature of the ICUs and criteria used for categorization for VAP[19].

International Nosocomial Infection Control Consortium (INICC) report between 2006 to 2021 showed that VAP is most common HAI in Low- and Middle-Income Countries (LMICs), which is linked to high mortality, prolonged hospitalization, additional expenses, and increased bacterial resistance[21,22].

Ventilator associated pneumonia is the one of health concern imposing both health and economic burden as it has been reported in different studies, VAP had additional bill charges an average of $40,000 in both developed and developing countries[19,23,24].

Mortality rates in critically ill patients requiring mechanical ventilation vary from 25% to 50% in various datasets, suggesting that VAP is an independent predictor of mortality in these patients. But those who get VAP are severely ill and prolonged stay in both intensive care unit and hospital[3]. A meta-analysis study revealed ventilator associated pneumonia an attributable mortality of 13%[25]

In Middle East countries and India, ventilator associated pneumonia incidence range 5.0 per 1,000 MV days to 40.1 occurrences per 1,000 MV days[12,15,24,26].

Studies conducted in South Africa documented incidence of 18% to 25%[4,18,20] and ventilator associated pneumonia mortality rate of 29% to 37.5% between 2013 to 2016[4,20].

In East Africa, a cross-section study at Kenyatta National Hospital intended to ascertain the prevalence of VAP and the diagnostic value of a pathogenic bacterial culture on tracheal aspirate in anticipating a positive culture on a mini-broncho alveolar lavage (Mini-BAL) by Amal et al in January to March of 2015 and Waweru et al on his randomized case control study aimed to ascertain if African patients receiving sucralfate as a stress-ulcer preventive medication are less likely than those receiving ranitidine to develop gastric colonization and ventilator-associated pneumonia showed VAP incidence of 54.4% and 20.6% respectively[2,9] While the study done in Uganda by Namutebi et al revealed VAP incidence of 38.3%[27]

1.1.3 Etiology of Ventilator Associated Pneumonia

Ventilator associated pneumonia (VAP) is caused by invasion of lower respiratory tract and lungs by pathogenic microorganisms. These pathogens typically gain access through the artificial airway establishment during mechanical ventilation.[3] Different pathogens have been associated with VAP, commonly gram-negative bacteria like *Pseudomonas aeruginosa, Acinetobacter baumannii, Klebsiella pneumoniae,* and *Escherichia coli* and gram positive such as *Staphylococcus aureus* (including methicillin-resistant strains, MRSA) and *Streptococcus pneumoniae*, however fungi (e.g. candida spp) and viruses e.g. influenza are rare in immune-competent patients[2,3,6]

1.1.3 Pathophysiology of Ventilator Associated Pneumonia

Ventilator associated pneumonia develops due to combination of disrupted host defenses, microbial invasion and inflammatory response triggered by mechanical ventilation.

Endotracheal tube (ETT) acts as a conduit for microorganisms and inhibits the mucociliary clearance and cough reflex allowing direct entry of pathogens to the lower respiratory tract.[3] Aerodigestive tract colonization by pathogenic organisms, Because of cuff leakage or inadequate sealing, micro-aspiration of oropharyngeal secretions carrying these pathogens might build above the ETT's cuff and leak into the lower respiratory tract. Pathogens also form biofilms on the surface of the ETT, providing a reservoir for persistent microbial release into the lungs likewise gastrointestinal and esophageal aspiration Opportunistic infections can colonize critically ill people due to alterations in their usual microbial flora[3].

When pathogens invade the alveoli, the body initiates an immune response involving neutrophils, macrophages, and cytokines. This inflammatory response leads to alveolar damage, increased capillary permeability, and the accumulation of inflammatory exudates in the alveoli, impairing gas exchange. Pathogen may spread into blood causing systemic inflammation which may result into sepsis and multi-organ dysfunction.[3]

1.1.5 Clinical Features of Ventilator Associated Pneumonia

Ventilator associated pneumonia (VAP) has non-specific clinical features like fever, copious or purulent tracheobronchial secretions, neutrophilia, and new or progressive lung infiltrates[6,10].

1.1.6 Diagnosis of Ventilator Associated Pneumonia

Ventilator associated pneumonia lacks specific clinical features and a gold standard diagnostic criterion; therefore, a diagnostic assessment is necessary as soon as this diagnosis is suspected[6,10]. A surrogate clinical marker for VAP called the Clinical Pulmonary Infection Score (CPIS) creates a numerical result with a score of ≥ 6 as a reasonably accurate indicator of the existence of VAP by combining clinical, radiological, physiological, and microbiological data. Other researchers have used CPIS to diagnose VAP,[2,4,28] CPIS have revealed high specificity and sensitivity in diagnosing VAP.[29,30]

1.1.7 Treatment of Ventilator Associated Pneumonia

When Ventilator associated pneumonia is diagnosed clinically without microbiologically confirmation, empirical antibiotics with wide coverage of microbes is initiated promptly while awaiting specific bacterium and its sensitivities are identified[1,3].

Both the geographical frequency of resistant microorganisms and the patient's risk factors for resistance should be taken into account during empirical treatment. Additionally, it takes into account the disease's onset time and potential pathogens, past antibiotic use, the severity and rate of the illness's progression, local pathogens and resistance patterns, and other patient-related aspects like hepatic and renal impairment[1,3].

1.1.8 Prevention of Ventilator Associated Pneumonia

Preventative measures focus on the three main ways that VAP arises: aspiration of secretions, colonization of the aerodigestive tract, and use of contaminated equipment. Measures includes effective hand washing by medical personnel, wearing protective gears i.e grown and gloves, adjusting the feeds to prevent stomach overstretching, avoid invasive mechanical ventilation when possible and daily evaluation for possible early extubation, preserve the ventilator circuit's integrity, sustain the appropriate endotracheal cuff pressure, using chlorhexidine for oral hygiene, head elevation about 30 to 40 degree and avoidance of unnecessary use of antibiotics[1,3,31]

1.2 Problem of statement

Ventilator-associated pneumonia (VAP) is considered the most common and severe nosocomial infection in Intensive Care Unit (ICU) settings acquired by patients who receiving mechanical ventilation[2,4,14,32]. Ventilator associated pneumonia affect approximately 5-40% of patient receiving mechanical ventilation and may reach up to 76% in some ICU settings[19,20], with significant increase use of hospital resources and mortality rate ranging from 24% to 50%[4,16,17]

Ventilator-associated pneumonia (VAP) arises from a combination of disrupted host defenses, microbial invasion, and inflammatory responses, with mechanical ventilation bypassing normal airway defenses and promoting pathogen entry into the lower respiratory tract[3,31]. Any factor that encourages secretory aspiration, aerodigestive tract colonization, or the use of contaminated equipment increases the risk of developing VAP. These factors may include (supine positioning, contaminated endotracheal tube or suction tube, coma, tracheostomy, reintubation, uncleared airway during intubation etc.)[3,31].

Different microbes reported to cause ventilator associated pneumonia (VAP) in different studies with different predominance in different geographical area, moreover same bacteria isolates differ on antibiotic susceptibility in different study area.[2,6] However less is known on prevalence, bacteriological pattern and antibiotics susceptibility of bacteria isolates linked with ventilator associated pneumonia in Tanzania.

1.3 Rationale

The economic and health burden of ventilator-associated pneumonia (VAP) is substantial. For example, patients with VAP incurred an additional average hospital bill of approximately $40,000 and had a significantly longer hospital stay (25.5 ± 22.8 days vs. 14.0 ± 14.6 days for those without VAP; $p < 0.01$) with median duration of ventilation in the VAP group was 249 hours as opposed to 65.5 hours in the non-VAP group with P-value of 0.0002 [4,19,23] and overall magnitude of antibiotics resistance is increasing[33,34]. Ventilator associated pneumonia being one of the most common causes of morbidity and mortality among mechanically ventilated patients.

This study findings may help to determine the extent of the problem (VAP) and give insight to bacteriological pattern and their antimicrobial sensitivity linked with ventilator associated

pneumonia in our setting, therefore it may contribute as a basis for improving and possibly formulating a policy brief on management of VAP on our setting and antibiotic stewardship.

This can help early initiation of appropriate antibiotics hence promoting reduction of hospital stay, unnecessary costs due unnecessary multiple antibiotics prescription and prolonged hospitalization as well as may help on mortality rate reduction.

1.4 Research questions

i. What is the magnitude of ventilator associated pneumonia among patients receiving invasive mechanical ventilation in intensive care units at Muhimbili?
ii. How is socio-demographic distribution among patients with ventilator associated pneumonia on invasive mechanical ventilation in intensive care units at Muhimbili?
iii. What are the clinical characteristics of the patients who developed ventilator associated pneumonia on invasive mechanical ventilation in intensive care units at Muhimbili?
iv. What is the bacteriological pattern linked with ventilator associated pneumonia among patients receiving invasive mechanical ventilation in intensive care units at Muhimbili?
v. What are the antimicrobial susceptibility profiles of pathogens isolated from patients with ventilator-associated pneumonia undergoing invasive mechanical ventilation in the intensive care units at Muhimbili, in relation to the commonly administered antibiotics?

1.5 Objective

1.5.1 Broad Objective

To determine the prevalence of ventilator associated pneumonia and antibiotics susceptibility of bacteria isolates linked with ventilator associated pneumonia among adult patients receiving invasive mechanical ventilation in intensive care units at Muhimbili.

1.5.2 Specific objective

i. To determine the prevalence of ventilator associated pneumonia (VAP) among invasive mechanically ventilated patients in ICU at Muhimbili.
ii. To determine socio-demographic factors (age, sex, smoking, history of drinking alcohol) of the patients who developed VAP connected to invasive mechanical ventilation in ICU at Muhimbili
iii. To determine clinical characteristics (admission diagnosis, comorbidities, indication for intubation) of the patients who developed VAP connected to invasive mechanical ventilation in ICU at Muhimbili?
iv. To determine bacteriological pattern among ventilator associated pneumonia patients receiving invasive mechanical ventilation for ≥ 48 hours in ICU at Muhimbili
v. To determine antibiotics susceptibility of bacteria isolates linked with VAP among patients receiving invasive mechanical ventilation for ≥ 48 hours in ICU at Muhimbili.

1.6 Conceptual framework/model

The conceptual framework for this study is designed to explore the multifaceted relationships between patient demographics, clinical characteristics, bacteriological patterns, and antibiogram profiles in determining the incidence of ventilator-associated pneumonia (VAP) among patients undergoing invasive mechanical ventilation at Muhimbili.

Independent Variables

The framework begins by considering patient demographics and clinical characteristics, which serve as independent variables. Patient factors such as age, sex, smoking history, and alcohol consumption can influence susceptibility to infections and recovery dynamics. Clinical characteristics, including the presence of comorbidities (e.g., diabetes or chronic respiratory conditions) or the number (burden) of comorbidities, create a baseline risk for VAP. For

example, patients with comorbidities who require mechanical ventilation often experience prolonged ventilation periods, which in turn increases their risk of exposure to potential pathogens.

Dependent Variable

The ultimate focus is the prevalence of ventilator-associated pneumonia (VAP), which is the dependent variable. The occurrence of VAP is influenced directly or indirectly by the independent and intermediate variables.

Intermediate Variables

The study identifies bacteriological patterns and antibiogram profiles as critical intermediate variables. The types of bacterial isolates associated with VAP and their distribution across different durations of mechanical ventilation provide insight into the microbiological landscape of infections. Moreover, the antibiotic susceptibility of these bacterial isolates is key to understanding treatment efficacy and the potential development of antibiotic resistance.

1.6.1 Independent variables

Age

Sex

Smoking history

History of alcohol consumption

Primary diagnosis for ICU admission (respiratory failure, cardiovascular conditions, neurological impairments, sepsis or kidney diseases etc)

Number of comorbidities (equal to 1 comorbidity verses equal or more than 2 comorbidities)

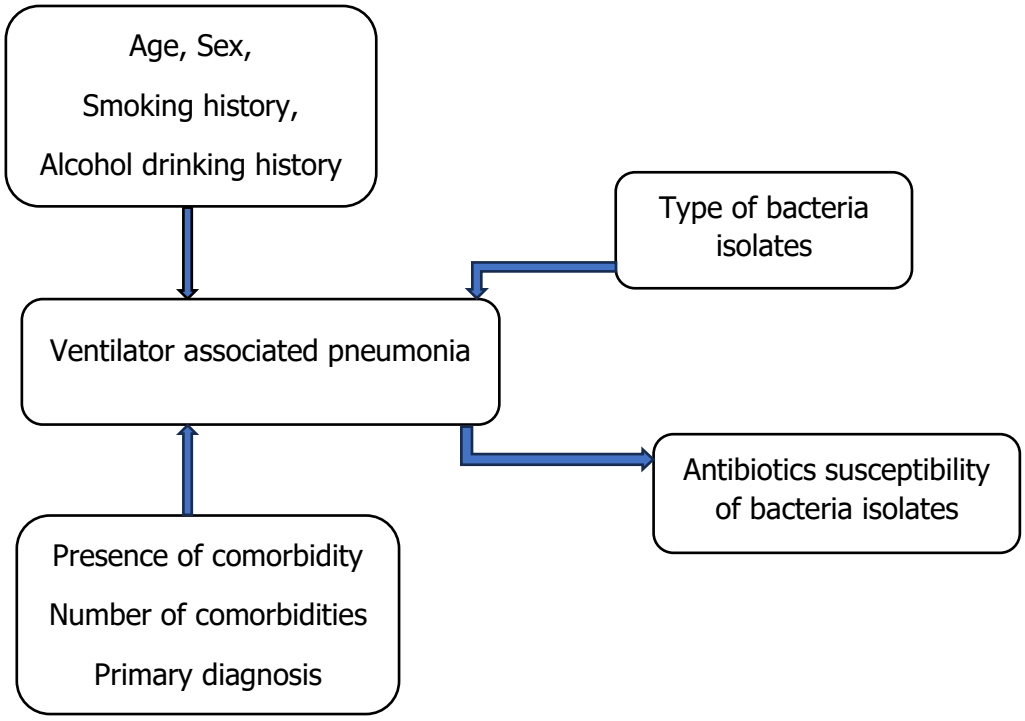
Type of bacteria isolates

Antibiotics susceptibility of bacteria isolates

1.6.2 Dependent variables

Ventilator associated pneumonia (VAP)

Figure 1: Interrelationship of the study variables



CHAPTER TWO

2.0 LITERATURE REVIEW

2.1 Socio-demographic characteristics among patients with VAP in ICU.

A multinational prospective cohort study involving more than 40 countries across 24 years in Asian, African, European, Latin American, and Middle Eastern countries by Rosenthal et al reported an association between male sex and ventilator associated pneumonia unlike age which showed no association[22]. Male sex was one of the six independent variables which increased the risk by 7% per day[22].

A large US retrospective study by Jordi Rello et al demonstrated that patients with VAP were considerably younger male, had intermediate deciles of illness severity, were more likely to be in a coma or stupor, and were more frequently traumatic patients[23].

Another prospective study done for 6 months by A.A Behari et al in Inkosi Albert Luthuli and King Edward VIII Hospital surgical intensive care units indicated that there was no statistically significant correlation observed between gender or age and the onset of VAP with P-value of 0.59 and 0.28 respectively[4].

Study done by Amal F et al who looked into different age groups which included pediatrics, adults and elderly group showed that the incidence did not differ statistically significantly among the age categories, and additional patient features could have played a role[2].

Rosenthal et al also reported type of ICUs reflecting severity of the disease versus mechanical ventilation demand, as pointed out Oncology adult ICU, Respiratory ICU and Neurology ICU had highest risk for VAP while Coronary ICU showed the lowest risk for VAP[22]. Likewise, Tejerina et al identified respiratory conditions like COPD, ARDS and aspiration of gastric contents as the primary cause for MV, were the most common risk for VAP[35]

2.2 Prevalence of VAP among mechanically ventilated patients in ICU.

Previous studies have reported wide variation in the incidence of ventilator-associated pneumonia (VAP) across different settings and populations. A large U.S. retrospective matched cohort study involving 9,080 mechanically ventilated patients found that 842 (9.3%) developed VAP[23]. In contrast, a 20-month prospective study at a tertiary care hospital in India by M.V.P. Charles et al. reported a much higher incidence of 23.7% among 76 ventilated patients, equivalent to 53.25 VAP episodes per 1,000 ventilator days[15]. Similarly, in South Africa, A. Awath Behari et al. observed that 25% of 32 ventilated patients developed VAP during a six-month study period[4]. A cross-sectional study conducted at Kenyatta National Hospital ICU between January and March 2015 by Amal F. and Sattar A. found an even higher incidence of 54.4% among 92 ventilated patients[2].

2.3 Bacteriological isolates linked with ventilator associated pneumonia.

Previous studies have consistently shown that Gram-negative bacilli are the predominant pathogens isolated from patients with ventilator-associated pneumonia (VAP), although the specific organisms and their frequencies vary across settings. Mazwi et al. reported that Gram-negative bacilli accounted for 41–92% of isolates in developing countries and about 60% in affluent countries, with *Pseudomonas aeruginosa* being the most common, followed by *Acinetobacter spp., Escherichia coli*, and *Klebsiella spp*.[20] Similarly, studies conducted in tertiary care hospitals in Pondicherry, India by N.M. Joseph et al. (2009) and in South Africa by A. Awath Behari et al. (2015) both demonstrated a predominance of *Pseudomonas aeruginosa* and *Acinetobacter baumannii* among VAP isolates[4,18].

However, Charles M.V.P. et al. (2011), in a prospective study on the incidence and risk factors of VAP in India, found *Pseudomonas aeruginosa* (33.3%) as the most frequently isolated pathogen, followed by *Klebsiella pneumoniae* (20.8%), while *Acinetobacter baumannii* (4.2%)

was among the least isolated. On the other hand, Amal F. et al. (2015) at Kenyatta National Hospital ICU reported a different pattern, with *Escherichia coli* (20%) and *Acinetobacter species* (20%) being the most prevalent isolates, whereas *Pseudomonas aeruginosa* (7%) was among the least recovered organisms[2,15].

2.4 Antibiotics susceptibility of culture isolates linked with VAP

Different studies have demonstrated a high and increasing burden of antimicrobial resistance (AMR) among pathogens causing ventilator-associated pneumonia (VAP), with significant clinical implications for patient outcomes. N.M. Joseph et al. reported that VAP patients who received inappropriate antibiotic therapy had a twofold higher risk of death (relative risk = 2.00, 95% CI, p = 0.0008)[11]. In a study conducted in India, among 74 VAP patients, there were 126 pathogenic isolates, with 44.6% having single-organism infections and 55.4% polymicrobial infections. Of these, 43.7% were multi-drug resistant (MDR), including Klebsiella spp. (26.6%), Pseudomonas spp. (20%), Acinetobacter spp. (25.5%), E. coli (14.5%), and coagulase-positive *S. aureus* (16.4%). Despite some sensitivity to broad-spectrum antibiotics such as meropenem, piperacillin, amikacin, colistin, and tigecycline, none showed more than 25% overall coverage against isolates, reflecting alarming resistance trends[17].

Similarly, A. Chaudhury et al. documented an increasing prevalence of MDR organisms among VAP patients, noting a rise in vancomycin-resistant enterococci (VRE) from 4% to 8.3% between 2012 and 2013, methicillin-resistant *Staphylococcus aureus* (MRSA) surpassing 50%, and very high resistance rates among Pseudomonas spp. to meropenem, piperacillin-tazobactam, and amikacin[36]. In another study by Rit K et al., involving mechanically ventilated patients, 20% developed VAP, and nearly 50% of cases were polymicrobial, yielding 43 isolates—of which 69.7% were MDR organisms, including beta-lactamase producers (ESBL, MBL, AmpC) and MRSA[26]. Antibiotic susceptibility profiling indicated that colistin was the most

effective agent, followed by imipenem and piperacillin–tazobactam, while ticarcillin and ampicillin were least effective. All MRSA and MSSA strains remained 100% sensitive to vancomycin. In late-onset VAP, colistin continued to be the preferred agent, except against A. baumannii, which showed 33% resistance[26].

In Kenya, a tertiary hospital study found that MRSA, Klebsiella spp., and Acinetobacter spp. were the most frequently isolated VAP pathogens. The majority of isolates exhibited resistance to first-line antibiotics, with the highest resistance seen to penicillin (95.2%), followed by cefotaxime (50%), and the lowest to ciprofloxacin (27.4%)[9].

Previous studies have reported inconsistent findings regarding the association of age and sex with the occurrence of ventilator-associated pneumonia (VAP). Furthermore, smoking and alcohol consumption have rarely been explored as potential risk factors, despite their well-established links to respiratory pathology. The relationship between age, sex, smoking, alcohol use and primary diagnosis in the development of VAP therefore remains unclear. Although considerable variability has been documented globally in the prevalence, bacterial profile, and antimicrobial susceptibility patterns of VAP-associated pathogens, there is a paucity of corresponding data from Tanzania.

CHAPTER THREE

3.0 METHODOLOGY

3.1 Study design

This study was a cross-section study among invasive mechanically ventilated patients admitted in intensive care units at Muhimbili (MNH, MOI and JKCI).

3.2 Study Area

The study was conducted in intensive care units at Muhimbili. These tertiary care hospitals located at upanga, Dar es salaam. They are three specialized institutions namely Muhimbili (MNH-Upanga), Muhimbili Orthopedic institution (MOI), Jakaya Kikwete Cardiac institute (JKCI), each of these institutions has ICU which offers different services including Mechanical ventilation, hemodialysis, central line catheterization etc.

MNH-Upanga ICU has two sections for surgical and medical comprising 4 and 3 cubicles respectively with a total of 23 bed capacity and 23 functional mechanical ventilators for cross-disciplinary patients while maternity ICU has 8 bed capacity with 8 functional ventilators. With an average of 35 patient monthly admissions in each ICU from emergency departments, theatre and transfer-in from different wards.

MOI-ICU has a total of 18 bed capacity and 18 functional ventilators, with an average of 30 patient monthly admission from emergency departments, theatre and transfer-in from different wards.

JKCI has medical and surgical ICU with total of 16 bed capacity, each ICU with 8 bed and 8 functional ventilators in each. With an average of 28 patient admission from emergency departments, theatre and transfer-in from different wards.

3.3 Population

3.3.1 General population

All adult patients admitted at Muhimbili (MNH, MOI and JKCI)

3.3.2 Target population

All patients who received invasive mechanical ventilation at muhimbili Intensive Care Units.

3.3.3 Study population

All invasive Mechanically ventilated patients in ICU who meets criteria obtained through appropriate recruitment method.

3.4 Sample size estimation

The sample size was calculated using the slovin's formula as shown below,

$$n = \frac{N}{1 + Ne^2}$$

Where; n = minimum sample size required

N = is total population

e = margin error of this study at 95% Cl which is = 0.05

From Hospital management information system (HMIS) of Muhimbili, ICUs average admission per month in year of each institution were as follows; MOI-ICU 30 admissions, JKCI-ICUs were 28 admissions, MNH-ICUs upanga were 105 admissions. This makes a total of 163 admission per month in all ICUs (study area). For the study duration of two months, this will make a total population 326 (163x2 admissions). With an assumption that 50% of all admissions will require invasive mechanical ventilation and they have no pneumonia/ARDs prior MV hence total population will be, N = 163.

Therefore, the minimum required sample size was, n = 115 distributed proportionally as 64.4% from MNH, 18.4% from MOI, and 17.2% from JKCI according to their respective patient populations.

Justification of formula

Study population was a finite population whereby all eligible participants could be enrolled for study and to obtain a representative sample within the given timeframe while maintaining statistical validity.

3.5 Sampling procedure and eligibility criteria.

Consecutive recruitment was used to recruit all eligible patients who have been on mechanical ventilation for more than or equal to 48 hours, the enrollment was done daily for all patients who met criteria.

3.5.1 Inclusion criteria

- All adult patients admitted in ICUs at Muhimbili who have been on mechanical ventilation for ≥ 48 hours were recruited

3.5.2 Exclusion criteria

- Patients who developed pneumonia prior to initiation of MV. These patients already have pneumonia, which is not associated with mechanical ventilation if those patients were included would have complicated to determine whether subsequent pneumonia is VAP.
- Patients who had been intubated outside the Muhimbili Intensive Care Units (ICUs) for more than 12 hours were excluded from this study. This decision was made to minimize potential confounding factors introduced by varying standards of aseptic technique and infection control practices at external facilities. Including such patients could have introduced additional heterogeneity unrelated to the specific ICU practices at Muhimbili,

potentially distorting the study results and complicating the attribution of pneumonia cases to ICU-specific ventilator-associated pneumonia (VAP) risk factors.

- Patients with acute respiratory distress syndrome. These patients might develop pneumonia due to factors intrinsic to ARDS (e.g., compromised lung defenses, inflammation) rather than factors specific to mechanical ventilation.
- Patients with chest drainage instruments

  All patients who have been on invasive mechanical ventilation for ≥ 48 hours who met criteria; The study was explained to the next of kin how will be carried out and what are the benefit can come out of this study and next of kin was asked for the written formal consent for the recruitment of the patient on the study.

  Recruitment of eligible patients was conducted on a daily basis until the desired sample size was achieved. The principal investigator and/or trained research assistants, who were registered medical officers purposefully selected based on their clinical experience and familiarity with intensive care unit procedures. They were recruited from each respective health facility where the study was conducted. Prior to data collection, all research assistants received orientation and training on the study objectives, inclusion criteria, data collection tools, and procedures to ensure consistency and accuracy in data handling. PI and/or trained research assistant were responsible for evaluating patients and enrolling them into the study.

3.6 Data collection – instruments, validity and reliability

Thermometer

An Omron digital thermometer, manufactured by the Omron Company in Shanghai, China, was used to measure axillary body temperature. It was tested against a standard reference thermometer routinely used at the MNH-ICU prior to its use on study patients

Arterial blood gas (ABG) machine

Abbott i-STAT 1 analyzer manufactured by Abbott company in United States (US), that enables acidity, blood gas and electrolytes testing, was used to analyze arterial blood gases for assessment of partial pressure of oxygen (hypoxemia). ABG machine (i-STAT 1) was calibrated and tested as its routine prior being used on the study sample.

Full blood picture machine

A Cell-Dyn Ruby 3700 analyzer, manufactured by Abbott Core Laboratory in the United States of America, was used for the differentiation and analysis of blood cells. The machine was calibrated and tested routinely prior to its utilization in this study.

Culture media plates

Blood Agar (BA), MacConkey Agar (MAC), and Sabouraud Agar (SA) media, manufactured by Oxoid Company in Basingstoke, Hampshire, United Kingdom, were used to identify and isolate microbes. These media were tested for color, clarity, pH, uniform thickness, and absence of contamination in prepared plates through sterility testing. Additionally, they were tested using reference microorganisms to confirm that they supported the growth of target organisms or inhibited non-target organisms in the case of selective media such as MacConkey Agar (MAC).

Sensitivity Disk

Oxoid sensitivity disks, manufactured by Oxoid Company in Basingstoke, Hampshire, United Kingdom, were used for antimicrobial susceptibility testing. The antimicrobial content, disk size, thickness, and material were ensured to meet the standards of the Clinical and Laboratory Standards Institute (CLSI)[37,38]. Disks were tested against reference strains of bacteria with known susceptibility profiles, and a single batch of disks was used throughout the study to maintain consistency in antimicrobial content and diffusion properties, as verified by the laboratory microbiologist.

Adopted questionnaire form

The structured questionnaire used in this study was adopted from a study done by K.R Njoki et al, as evidenced by its development process and prior use on the study of ventilator associated pneumonia. Minor modifications were made to align it with objective of this study, incorporating feedback from researchers and experts, including intensivists and pulmonologists, and guided by the study's theoretical framework.

3.7 Data Collection procedures

The principal investigator and/or carefully selected and trained research assistants, who were registered medical officers working in ICU settings, obtained a focused clinical history from the next of kin of study patients. Additional relevant clinical information was gathered from attending nurses, patient files, bedside charts, and the hospital management information system.

A structured questionnaire was used to collect data for all eligible patients who received invasive mechanical ventilation for ≥ 48 hours in the ICUs. The recorded information included: name, hospital number, age, sex, marital status, smoking and alcohol consumption habits, provisional or final diagnosis, date of ICU admission, date and time of intubation, indication for mechanical ventilation (e.g., respiratory failure, neurological impairments/impaired level of consciousness, airway obstruction, anesthesia complication, cardiovascular conditions), affected system (e.g., respiratory, cardiovascular, neurological), comorbidities (e.g., Hypertension, diabetes mellitus, Chronic kidney disease, chronic lung disease such as COPD, malignancy),number of comorbidities (none, one, two or more) antibiotic therapy prior to the onset of VAP, and the calculated CPIS for each mechanically ventilated patient.

3.7.1 Physical Examination Findings

- **Fraction of Inspired Oxygen (FiO_2)** — The set FiO_2 on mechanical ventilation required by each patient was recorded and evaluated in conjunction with partial pressure of oxygen and other clinical indicators (fever, desaturation, endotracheal secretions, lung consolidation) by the principal investigator and/or research assistants in relation to VAP.
- **Temperature** — An Omron digital thermometer was placed under the patient's armpit to measure axillary temperature. The temperature of each study patient was recorded after at least 48 hours on mechanical ventilation by the principal investigator and/or trained research assistant(s). A temperature greater than 38.5°C or less than 36.5°C was considered significant according to the CPIS.

3.7.2 Laboratory Investigations

- **Arterial Blood Gases (ABG)** — Standard sterilization procedures were followed, whereby the site for blood sample collection was wiped with a 5% alcohol swab, allowed to dry to avoid recontamination, and then arterial blood was collected using a 2cc heparinized syringe at ≥ 48 hours. The sample was analyzed within 10 minutes using the Abbott i-STAT 1 analyzer.
- **Full Blood Picture (FBP)** — Standard sterilization procedures were observed before sample collection. A 4 ml blood sample was collected in a purple-top tube containing the anticoagulant ethylenediaminetetraacetic acid (EDTA) at ≥ 48 hours for all study patients and sent to the Central pathology laboratory within 1 hour for analysis.

- **Endotracheal Aspirates (E.A) for microbiology study -** Endotracheal aspirates (E.A) were assessed for volume and color. E.A was classified as scanty if only a small amount barely covered the suction catheter and required suctioning only a few times per day (i.e., ≤ 4 times). Secretions were considered copious if they consistently occluded the suction catheter, necessitating frequent suctioning (e.g., hourly or more often). Finally, E.A was considered purulent if the secretions were thick, opaque, and off-white, yellow, or green in color, with an offensive odor.

  Endotracheal aspirates (E.A) were collected from every eligible patient who had adequate secretions, using a sterile mucus extractor (Polymed Mucus Extractor, Boulevard General, Wahis 531030 Brussels, Belgium) under strict aseptic conditions. Two healthcare workers participated in each sample collection to ensure sterility and proper technique: one inserted a sterile endotracheal suction catheter, connected to a sterile mucus extractor, was placed approximately 20 cm deep into the endotracheal tube to obtain at least 10 mL of broncho-tracheal secretions, while the other connected the opposite end to the suction machine to generate negative pressure. All specimens were immediately stored in cooling boxes and transported to the microbiology laboratory within 60 minutes of collection. Samples were then processed and analyzed at the Central Pathology Laboratory (CPL), including gram staining, culture, and antibiotic susceptibility testing.

3.7.3 Radiological investigations

- **Chest x-ray (CXR) -** a portable chest x-ray was used to take lung films in all study patients; film with infiltrate either localized or diffuse after 48 hours of mechanical ventilations on lung film was considered significant as stated in CPIS.

- The interpretation of chest X-ray findings was based on the official radiological reports issued by qualified radiologists uploaded on the hospital management information system. Chest X-ray findings recorded by the research team were cross-checked against the radiologist's written report and confirmed by the attending medical doctor(s) to ensure uniformity of diagnostic criteria and reduce inter-observer variability.

3.7.4 Laboratory data

- All study patients at Muhimbili ICUs underwent the following investigations: full blood picture (FBP), arterial blood gases (ABG), and endotracheal aspirate for culture and sensitivity. Results for these investigations were uploaded into the hospital management information system.
- All recorded parameters (FBP, ABG, E.A culture and sensitivity results) were documented in the structured data collection tool (Appendix II). Patients with a total white blood cell count greater than 11×10^9/L or less than 4.0×10^9/L, or a count of 11×10^9/L with an absolute neutrophil count predominance of $\geq7\times10^9$/L, were considered positive according to the CPIS.
- Arterial blood gases (ABG) with a partial pressure of oxygen (PaO_2) less than 60 mmHg were classified as indicating hypoxemia. The measured PaO_2 was compared with the recorded FiO_2 at the time of ABG sampling to calculate the PaO_2/FiO_2 ratio; a ratio of $\leq$ 240 mmHg was considered significant as per the CPIS criteria.
- Endotracheal aspirates whose gram stains showed more than 10 polymorphonuclear cells per low power field and at least one bacterium per oil immersion field, with or without intracellular bacteria, and quantitative cultures demonstrating $\geq 10^5$ CFU/mL, or isolation of the same pathogen as seen on gram stain, were deemed significant according to the CPIS.

Table 1: Modified Clinical Pulmonary Infection Score (CPIS)

PARAMETERS	SCORES	POINTS
Temperature ◦c	≥36.5 and ≤ 38.4	0
	≥38.5 and ≤38.9	1
	≥ 39 or ≤ 36.4	2
Total white blood cell count	≥4.0x10^9 /L and ≤11x10^9 /L	0
	<4.0x10^9 /L or >11x10^9 /L	1
	<4.0x10^9 /L or > 11x10^9 /L & band forms ≥ 50%	2
Tracheal secretions	scanty	0
	copious	1
	copious + pus like	2
P_aO_2 /FiO_2. ratio (mmHg)	>240 or ARDS	0
	-	-
	≤ 240 or no ARDS	2
Lung film	no infiltrate	0
	diffuse infiltrate	1
	localized infiltrate	2
Culture of endotracheal aspirate	Few quantities or no growth	0
	moderate or heavy growth	1
	Presence of the same pathogen on the gram stain	2

3.7.5 Bacterial Identification

Preliminary identification of the bacterial isolates was conducted by examining their microscopic features, colony morphology, and results from standard biochemical assays.

3.7.5.1 Conventional Biochemical Tests

For further identification, isolates were sub-cultured on nutrient agar (NA) to facilitate the performance of various biochemical tests. Gram-negative rods and cocci were characterized using tests such as carbohydrate fermentation, indole production, urease activity, citrate utilization, oxidase reaction, and Triple Sugar Iron (TSI) agar test. In cases where identification remained inconclusive, the Analytical Profile Index (API 20 E) system was employed for additional clarification. Identification of Gram-positive cocci was based on their Gram stain characteristics and supported by catalase and coagulase tests, DNase activity, Pyrrolidonyl Aminopeptidase (PYR) test, bacitracin sensitivity, and bile solubility assessment[38].

3.7.6 Antibiotic Susceptibility Testing

The antimicrobial susceptibility of the bacterial isolates was determined using the Kirby-Bauer disk diffusion technique, following the guidelines outlined by the Clinical and Laboratory Standards Institute (CLSI, 2024)[38]. For this procedure, three to five well-isolated colonies from a pure culture were picked and emulsified in 5 mL of normal saline to prepare a uniform bacterial suspension. The turbidity of this suspension was adjusted to match the 0.5 McFarland standard. A sterile cotton swab was dipped into the suspension, with excess fluid removed by gently pressing and rotating the swab along the inner wall of the tube. The swab was then used to evenly inoculate the entire surface of Mueller-Hinton Agar (MHA) plates. Inoculated plates were incubated at 37°C for 20–24 hours. After incubation, the diameters of the zones of inhibition around each antibiotic disk were measured in millimeters using Vernier calipers, and

results were interpreted as susceptible, intermediate, or resistant based on the CLSI 2024 breakpoints.

Reference strains *Staphylococcus aureus* ATCC 25923, *Escherichia coli* ATCC 25922, *Pseudomonas aeruginosa* ATCC 27853, and *Acinetobacter baumannii* ATCC 19606 were employed as quality control organisms. The selection of antibiotic disks for testing each bacterial species was carried out in accordance with the CLSI 2024 recommendations[38].

Antibiotic Discs Tested

For Gram-positive bacteria, the antimicrobial agents tested included amoxicillin/clavulanate (20/10 µg), gentamicin (10 µg), erythromycin (15 µg), tetracycline (30 µg), ciprofloxacin (5 µg), clindamycin (2 µg), trimethoprim/sulfamethoxazole (1.25/23.75 µg).

For Gram-negative isolates, the antibiotic disks applied comprised amoxicillin/clavulanate (20/10 µg), ceftriaxone (30 µg), ceftazidime (30 µg), cefotaxime (30 µg), gentamicin (10 µg), ciprofloxacin (5 µg), trimethoprim/sulfamethoxazole (1.25/23.75 µg), imipenem (10 µg), and meropenem (10 µg).

Specifically for *Pseudomonas aeruginosa*, the antibiotics tested included ceftazidime (30 µg), gentamicin (10 µg), ciprofloxacin (5 µg), piperacillin-tazobactam (100µg/10 µg), piperacillin (100 µg), cefepime (30 µg), and meropenem (10 µg).

For *Acinetobacter* species, the antibiotic panel consisted of ceftazidime (30 µg), gentamicin (10 µg), ciprofloxacin (5 µg), tetracycline (30 µg), piperacillin-tazobactam (100µg/10 µg), piperacillin (100 µg), cefepime (30 µg), and meropenem (10 µg).

To ensure accurate interpretation of inhibition zones, antibiotic disks were placed on the inoculated agar plates with a minimum distance of 15 mm from the plate edges and between disks to prevent overlapping zones.

Methicillin resistance among *Staphylococcus* isolates was determined using the cefoxitin disk method according to CLSI guidelines. Isolates exhibiting a zone of inhibition of 21 mm or less were classified as methicillin-resistant, while those with zones measuring 22 mm or greater were considered methicillin-susceptible.

Multidrug resistance (MDR) in this study was characterized as acquired resistance to at least one antibiotic in three or more distinct classes of antimicrobial agents. The antimicrobial classes evaluated included cephalosporins (ceftazidime, cefotaxime, ceftriaxone), aminoglycosides (gentamicin, amikacin), tetracyclines (tetracycline), fluoroquinolones (ciprofloxacin), folate pathway inhibitors (co-trimoxazole), macrolides (erythromycin), lincosamides (clindamycin), and carbapenems (imipenem or meropenem).

The study patient who has been on mechanical ventilation for 48 hours was evaluated for the onset of VAP using clinical, laboratory, and radiological findings. In the event that a patient was diagnosed with VAP as per standard definition set by Centre for Disease Control and Prevention (CDC) and National Healthcare Safety Network (NHSN)[1,3]. All patient with modified clinical pulmonary infection score (CPIS) ≥6 (Table 1), from whom endotracheal aspirate samples yielded bacterial isolates were classified as having microbiologically confirmed VAP. All relevant clinical, laboratory, and microbiological findings were documented in a structured data collection tool (Appendix V).

3.8 Data analysis

All collected data were entered and cleaned for consistency and errors before being analyzed using the Statistical Package for Social Sciences (SPSS) version 27. Descriptive statistics were employed to summarize the socio-demographic and clinical characteristics of study participants. Categorical variables were presented as frequencies and percentages, while

numerical variables were summarized using means and standard deviations or medians and interquartile ranges, as appropriate.

Comparisons between groups were conducted using the Chi-square test or Fisher's exact test, depending on data distribution and cell sizes. Bivariate analyses were performed to assess the association between selected independent variables and the dependent variable, with corresponding 95% confidence intervals and p-values reported. Variables with a p-value less than 0.2 in the bivariate analysis were included in a multivariate regression model to adjust for potential confounders. In the multivariate analysis, a p-value of less than 0.05 was considered statistically significant. Tables, charts and text were used to present results.

3.9 Ethical Approval

3.9.1 Ethical clearance

Ethical clearance for this study was obtained from the Kairuki University Institutional Research and Ethics Committee (IREC). In addition, permission to conduct the study was granted by the research administrative bodies and executive directors of Muhimbili National Hospital (MNH-Upanga), Muhimbili Orthopaedic Institute (MOI), and Jakaya Kikwete Cardiac Institute (JKCI).

3.9.2 Ethical consideration

Prior to data collection, the purpose, objectives and procedures for this study were clearly explained to all eligible patients and/or their next of kin, written informed consent was obtained from the next of kin. For those who were incapable of signing documents by hand, a thumbprint was used as an acceptable alternative to a handwritten signature on the consent form. Participants were informed about the possibility of experiencing minor pain or discomfort during sample withdrawal, which was expected to resolve immediately following the procedure. Furthermore, the attending clinicians responsible for the care of study participants

were promptly notified of any abnormal vital signs or laboratory results to ensure timely and appropriate clinical interventions

To ensure confidentiality and protect participants' identities, only initials and study identification numbers were used in data collection tools instead of names. All collected data were securely stored, both in paper form and electronically. Electronic data were password-protected and accessible only to authorized personnel. Data analysis was performed on de-identified datasets to maintain participant anonymity throughout the research process.

3.10 Data Dissemination

At the end of this study, research findings will be presented to the department of Internal Medicine. The final report submitted and available at the Kairuki University (KU) Library for reference. The results will also be presented in scientific conferences and published in a peer-reviewed medical journal.

CHAPTER FOUR

4.0 RESULTS

A total of 157 patients who had been on invasive mechanical ventilation (MV) for ≥48 hours were approached across all three tertiary hospitals at muhimbili (MNH, MOI and JKCI) during the two-month data collection window. They were assessed for eligibility, and those who met the inclusion criteria and provided consent were consecutively recruited into the study. A total of 119 patients were recruited over two-month period (May-June 2025), which slightly exceeded the minimum calculated sample size of 115.

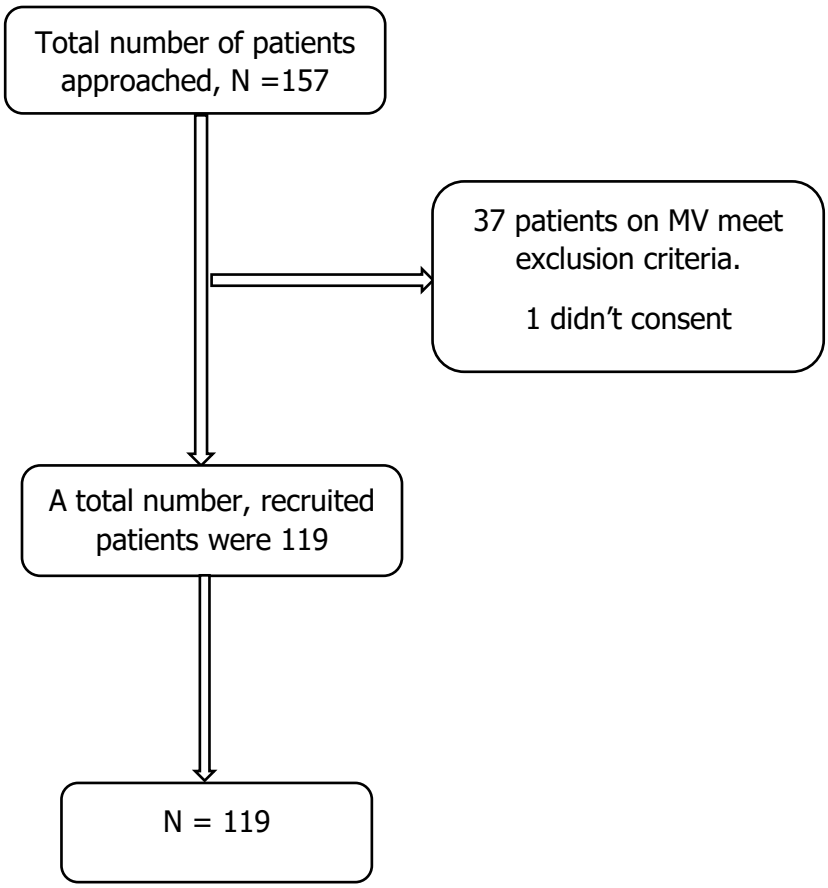


Figure 2: consort flowchart showing patient recruitment.

4.1 baseline (socio-demographic and clinical) characteristics of study population

The study included 119 patients, with most aged 18–44 years (45.4%) and a slight majority being male (58.8%). The majority had no history of smoking (80.7%), and 44.5% reported alcohol use. Neurological impairments (31.9%) and respiratory failure (30.3%) were the most common reasons for mechanical ventilation. Majority of patients (82.4%) had at least one comorbidity.

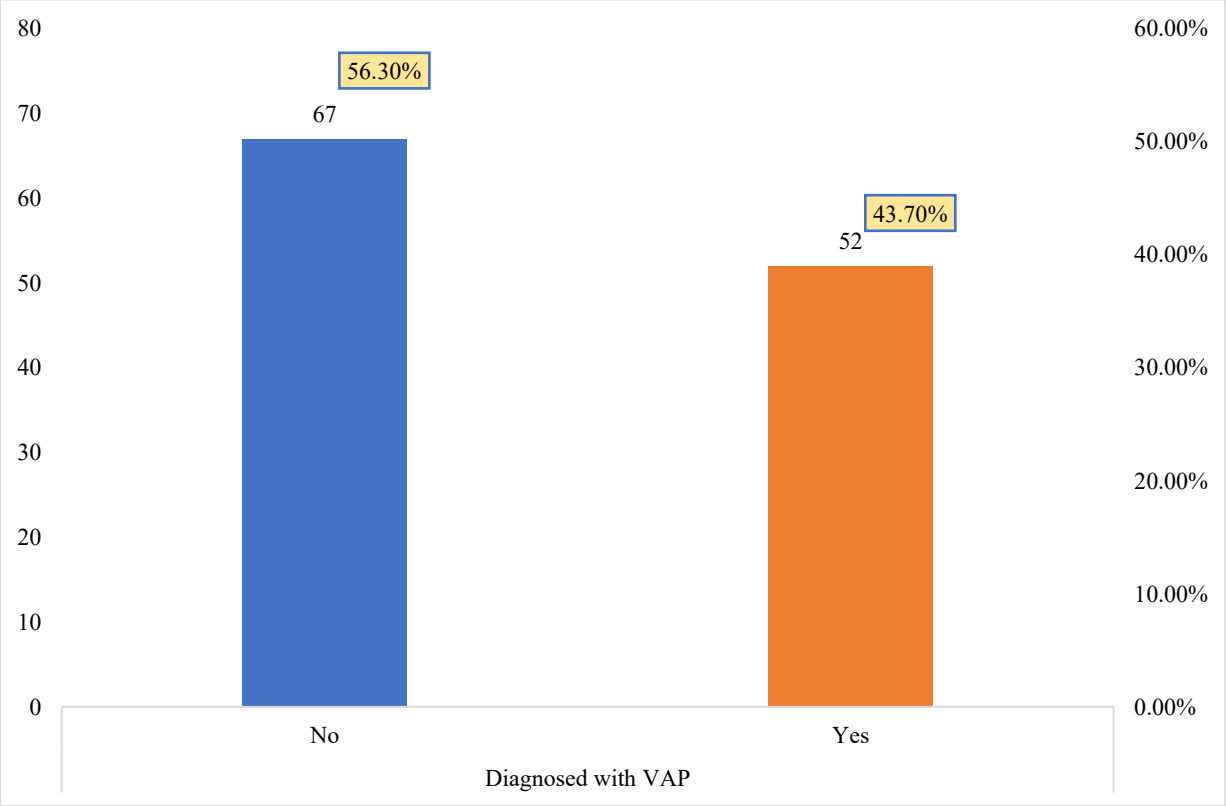
4.2 The prevalence of ventilator associated pneumonia (VAP) among invasive mechanically ventilated patients at Muhimbili intensive care units.

Out of a total of 119 participants, 52 (43.7%) were diagnosed with ventilator-associated pneumonia (VAP). This indicates that VAP affected nearly half of the mechanically ventilated patients in the study. The bar chart (Figure 3) illustrates the distribution of patients based on their diagnosis of ventilator-associated pneumonia (VAP).

Table 2: Distribution of baseline characteristics of study population, (N = 119).

Variable	Category	N	%
Age Categories	18–44	54	45.4%
	45–59	25	21.0%
	60+	40	33.6%
Sex of Participants	Female	49	41.2%
	Male	70	58.8%
History of Smoking	Yes	23	19.3%
	No	96	80.7%
History of Drinking Alcohol	Yes	53	44.5%
	No	66	55.5%
Type of Antibiotic in Use	Single	85	71.4%
	Two or More	34	28.6%
Primary Diagnosis	Cardiovascular conditions	3	2.5%
	Neurological Impairments	38	31.9%
	Post-Surgical Complications	3	2.5%
	Respiratory Failure	36	30.3%
	Sepsis	24	20.2%
	Trauma	9	7.6%
	Anesthetic Complications	3	2.5%
	Others	3	2.5%
Number of Comorbidities	None	21	17.6%
	One	71	59.7%
	Two or More	27	22.70%
Presence of Comorbidity	No	21	17.6%
	Yes	98	82.4%

Figure 3: Prevalence of VAP among invasive mechanically ventilated patients at Muhimbili intensive care units, N=119



Key:

No VAP VAP

4.3 Distribution of socio-demographic factors (age, sex, smoking history, history of drinking alcohol) of the patients who developed VAP while receiving invasive mechanical ventilation at Muhimbili intensive care units.

Out of the 119 patients, 52 (43.7%) who were diagnosed with ventilator-associated pneumonia (VAP), and the distribution of VAP cases across key demographic and social variables were as shown on the table 3.

Table 2: Socio-demographic Distribution among patients who received invasive mechanical ventilation at Muhimbili intensive care units, (N = 119).

Variable	Category	Diagnosed with VAP		
		Yes	No	Total
Age Category				54
	18–44	9 (16.7%)	45 (83.3%)	(100%)
				25
	45–59	15 (60.0%)	10 (40.0%)	(100%)
				40
	60+	28 (70.0%)	12 (30.0%)	(100%)
Sex				49
	Female	16 (32.7%)	33 (67.3%)	(100%)
				70
	Male	36 (51.4%)	34 (48.6%)	(100%)
History of Smoking				23
	Yes	10 (43.5%)	13 (56.5%)	(100%)
				96
	No	42 (43.8%)	54 (56.3%)	(100%)
History of Drinking Alcohol				53
	Yes	21 (39.6%)	32 (60.4%)	(100%)
				66
	No	31 (47.0%)	35 (53.0%)	(100%)

The occurrence of VAP increased with age, with the highest proportion observed among patients aged 60 years and above 70.0% (n = 28), followed by those aged 45–59 years 60.0% (n = 15), while only 16.7% (n = 9) of those aged 18–44 years developed VAP. Male participants had a higher prevalence of VAP compared to females (51.4% vs. 32.7%).

With respect to lifestyle factors, smoking history showed no notable difference, as 43.5% (n = 10) of smokers and 43.8% (n = 42) of non-smokers developed VAP. Similarly, alcohol consumption did not appear to strongly influence VAP occurrence, with 39.6% (n = 21) of drinkers and 47.0% (n = 31) of non-drinkers being affected.

4.4 Clinical characteristics (primary diagnosis, presence of comorbidity, number of comorbidities) of the patients who developed VAP while receiving invasive mechanical ventilation at Muhimbili intensive care units.

Table 4 below, shows distribution of clinical characteristics among patients who received invasive mechanical ventilation at Muhimbili intensive care units. Ventilator-associated pneumonia (VAP) was observed most frequent among those admitted with post-surgical complications (66.7%) and neurological impairments (60.5%), whereas lower proportions were observed in patients with cardiovascular conditions (33.3%), sepsis (29.2%), and none (0.00%) in those with anesthetic complications.

A higher proportion of patients with comorbidities developed VAP (45.5%) relative to those without comorbidities (33.3%), and the likelihood increased with the number of comorbidities, from 29.2% in patients with no comorbidity, to 40.8% in those with at least one comorbidity, and 66.7% in those with two or more comorbidities, indicating p of comorbidity burden could increase the risk of ventilator associated pneumonia among mechanically ventilated patients in intensive care units.

Table 3: Clinical characteristics distribution among patients who received invasive mechanical ventilation at Muhimbili intensive care units, (N =119).

Variable	Category	VAP	
		Yes	No
Primary Diagnosis	Cardiovascular conditions	1 (33.3%)	2 (66.7%)
	Neurological Impairments	23 (60.5%)	15 (39.5%)
	Post-Surgical Complications	2 (66.7%)	1 (33.3%)
	Respiratory Failure	14 (38.9%)	22 (61.1%)
	Sepsis	7 (29.2%)	17 (70.8%)
	Trauma	4 (44.4%)	5 (55.6%)
	Anesthetic Complications	0 (0.0%)	3 (100.0%)
	Others	1 (33.3%)	2 (66.7%)
Presence of comorbidity	No	6 (33.3%)	12 (66.7%)
	Yes	46 (45.5%)	55 (54.5%)
Number of comorbidities	None	7 (29.2%)	17 (70.8%)
	One	29 (40.8%)	42 (59.2%)
	Two or More	16 (66.7%)	8 (33.3%)

Table 4: association between patient characteristics and the presence of ventilator-associated pneumonia among invasive mechanically ventilated patients at Muhimbili intensive care units, (N=119).

Variable	Category	COR (95% CI)	p-value
Age (years)	18–44	Ref	<**0.001**
	45–59	7.50 (3.00–18.75)	
	60+	11.67 (5.10–26.70)	
Sex	Female	Ref	**0.042**
	Male	2.26 (1.02–5.00)	
Smoking History	Yes	1.01 (0.40–2.53)	0.981
	No	Ref	
Alcohol Use	Yes	Ref	0.422
	No	1.37 (0.63–2.99)	
Antibiotics Use	Single	Ref	0.199
	Two or more	1.69 (0.75–3.82)	
Primary Diagnosis	Anesthetic Complications	0.00 (—)	0.188
	Cardiovascular	Ref	
	Neurological Impairments	6.89 (0.52–90.72)	
	Others	1.00 (0.05–20.90)	
	Post-surgical Complications	9.00 (0.44–183.38)	
	Respiratory Failure	2.20 (0.18–26.98)	
	Sepsis	1.47 (0.11–19.29)	
	Trauma	1.45 (0.09–22.75)	
Comorbidity	No	Ref	0.336
	Yes	1.65 (0.61–4.43)	
Number of Comorbidities	None	Ref	**0.058**
	One	1.71 (0.67–4.39)	
	Two or more	4.95 (1.45–16.86)	

A bivariate analysis was performed to assess the association between selected patient characteristics and the development of ventilator-associated pneumonia (VAP) among invasive mechanically ventilated patients at Muhimbili intensive care units, several findings were revealed as depicted on table 5 above.

Age was found to have a strong and statistically significant association with the development of VAP (P value < 0.001). Using patients aged 18–44 years as the reference group, those aged 45–59 years had 7.50 times higher odds of developing VAP, while those aged 60 years and above had 11.67 times higher odds. This demonstrates a clear trend, where the likelihood of VAP increased substantially with advancing age.

Sex was also significantly associated with VAP occurrence (P value = 0.042). Male patients were more affected, with 2.26 times higher odds of developing VAP compared to female patients. These findings suggest that male sex may be an independent risk factor for VAP in invasive mechanically ventilated patients within this population.

On the other hand, lifestyle factors such as smoking history and alcohol consumption were not significantly associated with VAP risk (P value = 0.981). Smoking history showed no meaningful effect on the development of VAP as smokers and non-smokers had nearly identical odds (CoR: 1.01; 95% CI: 0.40–2.53). Similarly, alcohol consumption did not demonstrate a significant association (P = 0.422). Patients who did not consume alcohol had slightly higher odds of VAP (CoR: 1.37; 95% CI: 0.63–2.99), though the finding was not statistically significant. These results indicate that lifestyle factors were not contributors to VAP risk in this cohort.

The use of antibiotics was also examined, comparing patients who received a single antibiotic to those who received two or more. Although participants on multiple antibiotics had marginally higher odds of developing VAP (CoR: 1.69; 95% CI: 0.75–3.82), the association was

not statistically significant (P = 0.199). This suggests that the number of antibiotics in use did not meaningfully influence the risk of VAP in this study population.

When assessing primary diagnosis for ICU admission, no statistically significant relationship with VAP was observed (P = 0.188). While patients admitted for neurological impairments and post-surgical complications appeared to have higher crude odds of developing VAP (CoR: 6.89 and 9.00, respectively), the wide confidence intervals and non-significant p-value indicate that these associations should be interpreted with caution.

The role of comorbidities was also explored. The presence of any comorbidity was not significantly associated with the development of VAP (P = 0.336). However, when the number of comorbidities was considered, a clearer trend was observed. Although the association between number of comorbidities and VAP approached statistical significance (P = 0.058), only participants with two or more comorbidities showed significantly increased odds of developing VAP (CoR: 4.95; 95% CI: 1.45–16.86) when compared to those with no comorbidities. This suggests that the burden of comorbid conditions may contribute to the risk of VAP.

Taken together, these findings highlight that older age and male sex were significant predictors of VAP in this study population, while a higher number of comorbidities showed a borderline association. In contrast, smoking, alcohol use, type of antibiotic in use, and primary diagnosis for ICU admission did not demonstrate significant associations with VAP. To further clarify independent predictors while accounting for potential confounding, a multivariate logistic regression analysis was performed. The results are presented in Table 6 below, with adjusted odds ratios (AOR), 95% confidence intervals (CI), and corresponding p-values

Table 5: Logistic regression analysis of factors associated with VAP among invasive mechanically ventilated patients at Muhimbili intensive care units, (N=119).

Variable	Category	COR (95% CI)	p-value	AOR (95% CI)	p-value
Age Categories	18–44	Ref		Ref	
	45–59	7.50 (3.00–18.75)	<.001	9.521 (2.872–31.565)	**<.001**
	60+	11.67 (5.10–26.70)		11.507 (3.726–35.536)	
Sex	Female	Ref	0.042	Ref	
	Male	2.26 (1.02–5.00)		1.790 (0.652–4.913)	0.258
Antibiotics Use	Single	Ref	0.199	Ref	
	Two or More	1.69 (0.75–3.82)		1.608 (0.573–4.513)	0.367
Primary Diagnosis	Cardiovascular	Ref		Ref	
	Neurological Impairments	6.89 (0.52–90.72)		5.848 (0.315–108.536)	0.236
	Post-Surgical Complications	9.00 (0.44–183.38)		4.995 (0.071–351.970)	0.459
	Respiratory Failure	2.20 (0.18–26.98)	0.188	2.831 (0.150–53.473)	0.488
	Sepsis	1.47 (0.11–19.29)		1.330 (0.068–26.028)	0.851
	Trauma	1.45 (0.09–22.75)		5.482 (0.200–150.064)	0.314
	Others	1.00 (0.05–20.90)		1.933 (0.039–95.888)	0.741
Number of Comorbidities	None	Ref		Ref	
	One	1.77 (0.65–4.81)	0.058	1.082 (0.274–4.273)	0.91
	Two or more	4.95 (1.45–16.86)		1.940 (0.359–10.502)	0.442

The multivariate analysis identified Age as significant independent predictor of VAP. Compared to patients aged 18–44 years (reference group), those aged 45–59 years had 9.52 times higher odds of developing VAP (OR = 9.521; 95% CI: 2.872–31.565; $p < 0.001$). Similarly, patients aged 60 years and above had 11.51 times greater odds of developing VAP (OR = 11.507; 95% CI: 3.726–35.536; $p < 0.001$). These findings suggest a strong and statistically significant association between advancing age and increased risk of VAP, independent of other factors. The only statistically significant and independent predictor of VAP among ICU patients in this study. Other variables, including sex, antibiotic use, primary diagnosis, and number of comorbidities, did not show significant associations after adjusting for confounders as depicted on the table 6.

4.5 bacteriological pattern among ventilator associated pneumonia patients who received invasive MV for ≥ 48 hours at Muhimbili intensive care units.

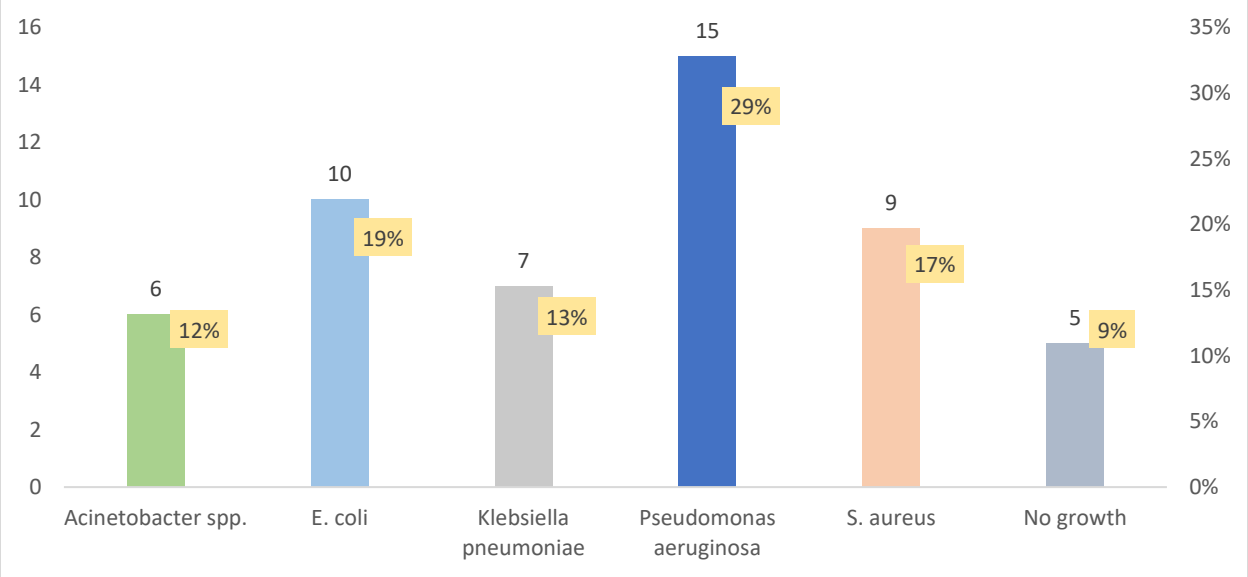


Figure 4: Bacteriological pattern among VAP patients at Muhimbili intensive care units, (n/N=52/119)

4.6 Antibiotics susceptibility pattern of bacteria isolates among patients diagnosed with ventilator associated pneumonia while on invasive mechanical ventilation at Muhimbili intensive care units.

Table 6: AST BREAK POINTS AMONG ISOLATED BACTERIA ASSOCIATED WITH VAP

Antimicrobial Agent	E. coli (n=10(S/I/R)	Klebsiella (n=7) (S/I/R)	P.aeruginosa (n=15) (S/I/R)	Acinetobacter spp (n=6) (S/I/R)	S.aureus (n=9) (S/I/R)
Ampicillin 10µg	-	1/0/6	-	-	-
Amikacin 30µg	7/1/2	5/1/1	-	-	-
Amoxicillin-Clavulanate (AMC/AUG) 20/10µg	4/0/6	0/1/6	-	-	-
Piperacillin/Tazobactam (TZP) 100/10µg	8/0/3	4/0/3	9/0/6	1/0/5	-
Cefepime 30µg	6/1/3	4/0/3	7/1/7	0/1/5	-
Ceftriaxone 30µg/ Cefotaxime 30µg	4/0/6	4/0/3	-	-	-
Cefoxitin 30µg	-	-	-	-	7/0/2
Ceftazidime 30µg	4/1/5	2/1/4	6/0/9	0/0/6	-
Imipenem 10µg or Meropenem 10µg	8/0/2	7/0/0	11/0/4	4/0/2	-
Gentamycin 10µg or Tobramycin 10µg	2/0/8	2/1/4	5/0/10	0/0/6	-
Azithromycin 15µg	-	-	-	-	-
Tetracycline 30µg or Doxycycline 30µg	-	-	-	-	1/0/8

Antimicrobial Agent	E. coli (n=10(S/I/R)	Klebsiella (n=7) (S/I/R)	P.aeruginosa (n=15) (S/I/R)	Acinetobacter spp (n=6) (S/I/R)	S.aureus (n=9) (S/I/R)
Ciprofloxacin 5µg	2/2/6	2/0/5	4/3/8	0/0/6	2/1/6
Trimethoprim/Sulfamethoxazole 1.25/23.75µg	0/1/9	0/0/7	-	0/0/6	-
Clindamycin 2µg	-	-	-	-	2/0/7
Piperacillin 100µg	-	-	9/0/6	1/0/5	-
Erythromycin 15µg		-	-	-	0/1/8

S = Susceptible, I = Intermediate, R = Resistant, (-) =not applicable

Table 8: Pattern of antibiotic susceptibility of bacteria isolates on common regularly administered antibiotics to mechanically ventilated patients at Muhimbili intensive care units.

Antibiotic	Organism	Susceptible (%)	Resistant (%)
Meropenem	E. coli (n=10)	80.00%	20.00%
	Klebsiella (n=7)	100.00%	0.00%
	P. aeruginosa (n=15)	73.30%	26.70%
	Acinetobacter spp (n=6)	66.70%	33.30%
Ceftriaxone	E. coli (n=10)	40.00%	60.00%
	Klebsiella (n=7)	57.10%	42.90%
Piperacillin-Tazobactam	E. coli (n=10)	72.70%	27.30%
	Klebsiella (n=7)	57.10%	42.90%
	P. aeruginosa (n=15)	60.00%	40.00%
	Acinetobacter spp (n=6)	16.70%	83.30%
Clindamycin	S. aureus (n=9)	22.20%	77.80%

The findings revealed that carbapenems (Meropenem) remain highly effective against most Gram-negative bacteria. Klebsiella exhibited full susceptibility (100%), followed by E. coli (80%) and Pseudomonas aeruginosa (73.3%). However, Acinetobacter spp. showed a worrying resistance rate of 33.3%, signaling emerging resistance even to last-resort antibiotics.

In contrast, Ceftriaxone, a commonly used third-generation cephalosporin, demonstrated significant resistance. E. coli showed a high resistance rate (60%), while Klebsiella exhibited moderate resistance (42.9%).

These findings suggest the possible presence of extended-spectrum beta-lactamase (ESBL) producing strains, making ceftriaxone increasingly unreliable for empirical treatment of Enterobacteriaceae infections.

Piperacillin-Tazobactam (TZP) showed varied effectiveness. While E. coli (72.7%) and P. aeruginosa (60%) had moderate susceptibility, Klebsiella (57.1%) displayed lower sensitivity. Alarmingly, Acinetobacter spp. had a very high resistance rate (83.3%), rendering TZP largely ineffective for treating infections caused by this pathogen.

Lastly, Clindamycin was notably ineffective against Staphylococcus aureus, with a resistance rate of 77.8%. Resistant to Cefoxitin was 2 out of 9 (22.2%), which indicates low prevalence of MRSA. Thus, phenotypic resistance observed may reflect non-mecA mediated resistance mechanisms or inducible clindamycin resistance (iMLS), necessitating confirmatory susceptibility testing before clindamycin use.

4.6.1 multi-drug-resistant bacteria isolated among patients diagnosed with VAP.

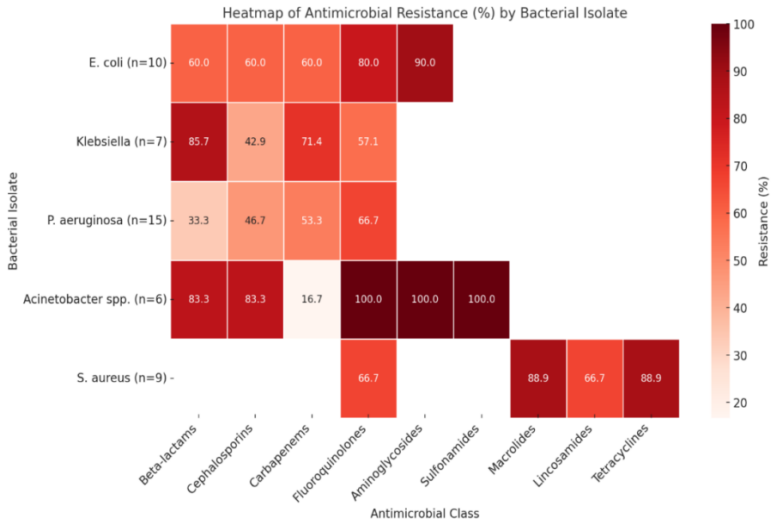


Figure 5: Heatmap of antimicrobial resistance among bacteria isolated in ICU among patients diagnosed with ventilator associated pneumonia.

Among E. coli isolates (10), MDR was confirmed. Resistance was observed in 6 (60.0%) to beta-lactams (Amoxicillin-Clavulanate), 6 (60.0%) and 5 (50.0%) to cephalosporins (Ceftriaxone and Ceftazidime), 6 (60.0%) to fluoroquinolones (Ciprofloxacin), 9 (90.0%) to sulfonamides (Trimethoprim/Sulfamethoxazole), and 8 (80.0%) to aminoglycosides (Gentamycin), indicating a clear MDR pattern.

For Klebsiella pneumoniae (7), MDR was similarly evident. Resistance to beta-lactams was found in 6 isolates (85.7%). Within the cephalosporin class (Ceftriaxone) was observed in 3 isolates (42.9%), and to Ceftazidime in 4 isolates (57.1%). Resistance to fluoroquinolones (Ciprofloxacin) was recorded in 5 isolates (71.4%), and 4 isolates (57.1%) were resistant to aminoglycosides. The extent of resistance across these key antibiotic classes fulfills the criteria for MDR classification.

Among Pseudomonas aeruginosa isolates (15), a widespread MDR profile was detected. Resistance to beta-lactams (Piperacillin-Tazobactam) occurred in 5 isolates (33.3%). For cephalosporins, 7 isolates (46.7%) were resistant to Cefepime and 9 isolates (60.0%) to Ceftazidime. Resistance to fluoroquinolones (Ciprofloxacin) was observed in 8 isolates (53.3%), while 10 isolates (66.7%) were resistant to aminoglycosides. These findings indicate a moderately high MDR level within this group.

For Acinetobacter spp. (6), a severe MDR profile was observed, with resistance to nearly all tested classes. Resistance to beta-lactams (Piperacillin-Tazobactam) was seen in 5 isolates (83.3%). Resistance to cephalosporins was substantial, with 5 isolates (83.3%) resistant to Cefepime and 6 isolates (100.0%) to Ceftazidime. Carbapenem resistance was identified in 1 isolate (16.7%), Alarmingly, all 6 isolates (100.0%) were resistant to fluoroquinolones, aminoglycosides, and sulfonamides suggesting potential extensive drug resistance (XDR).

In S. aureus (9), resistance was found in 6 (66.7%) to fluoroquinolones, 8 (88.9%) to macrolides, 6 (66.7%) to lincosamides, and 8 (88.9%) to tetracyclines. Only 2 (22.2%) were resistant to Cefoxitin, indicating a low MRSA prevalence, but high non-beta-lactam resistance suggests possible MDR.

CHAPTER FIVE

5.0 DISCUSSION

5.1 Ventilator associated pneumonia prevalence

This study demonstrated a VAP prevalence of 43.7% among mechanically ventilated adult patients at Muhimbili intensive care units (ICUs). This prevalence is notably higher than global averages, compared to developed countries, where VAP prevalence typically ranges between 5–20% depending on ICU type and diagnostic criteria, the prevalence observed in this study is significantly elevated[16,19,23]. However, it aligns with findings from regional studies, for instance, Amal et al. (2018) reported a VAP incidence of 54.4% at Kenyatta National Hospital, while Waweru et al. (2015) documented 41.1% in a similar setting[2,9].

The high prevalence observed in this setting may reflect variations in ICU infrastructure, staffing ratios, infection prevention protocols, and differences in diagnostic approaches. Factors such as resource constraints, late initiation of preventive measures, prolonged mechanical ventilation, and suboptimal antibiotic stewardship may further contribute to increased VAP rates in low- and middle-income countries (LMICs), as highlighted in INICC reports[19,21].

5.2 Socio-Demographic and Clinical Characteristics of Patients with VAP

The current study identified several studied factors are associated with VAP development. Age emerged as a significant independent predictor. Patients aged 45–59 years had a 9.52-fold increased risk, while those aged ≥60 years had an 11.51-fold higher risk of developing VAP compared to those aged 18–44 years. These findings are consistent with global literature indicating that older adults exhibit heightened susceptibility to nosocomial infections, partly due to immunosenescence, multiple comorbidities, and physiological decline in respiratory defense mechanisms[1,16].

Smoking showed no significant association with VAP development in this cohort. This finding diverges from other international studies where smoking has been implicated as a potential risk factor due to impaired mucociliary clearance[9,20,22]. However, the small proportion of smokers (19.3%) in this study may have limited the power to detect significant associations.

Additionally, although the presence of multiple comorbidities appeared to increase the risk of VAP, this association did not reach statistical significance in the multivariate models, which may be attributable to sample size limitations. Nevertheless, the observed trend indicates that the burden of chronic illnesses may contribute to heightened vulnerability, as comorbidities impair immune function, reduce physiological reserve, and frequently necessitate prolonged ICU stays and mechanical ventilation. These factors increase susceptibility to bacterial colonization and elevate the risk of VAP, consistent with other previous studies[19,20].

5.3 Bacteriological Patterns Associated with VAP

The bacteriological profile in this study revealed that *Pseudomonas aeruginosa* was the predominant pathogen isolated from patients with ventilator-associated pneumonia (VAP), accounting for 29% of all positive cultures. This finding aligns with multiple international studies, including those conducted by Mazwi et al. and Charles et al., which consistently identified Pseudomonas aeruginosa as a leading cause of VAP, particularly due to its ability to form biofilms on endotracheal tubes and its intrinsic antibiotic resistance mechanisms[4,20,39].

Other significant isolates included *Escherichia coli* (19%), *Staphylococcus aureus* (17%), *Klebsiella pneumoniae* (13%), and *Acinetobacter spp.* (12%). The predominance of Gram-negative bacilli, particularly Enterobacteriaceae and Acinetobacter species, mirrors patterns observed in low- and middle-income countries, where these organisms are frequently implicated with VAP in ICU patients[11,20].

This may be explained by fact that patients on mechanical ventilation often become colonized in the oropharynx and gastrointestinal tract with Gram-negative Enterobacteriaceae. These organisms can then translocate into the lower respiratory tract via aspiration or biofilm formation on endotracheal tubes. Also, the ability of gram-negative organisms like Acinetobacter spp. and Klebsiella thrive in the hospital environment, particularly in humid surfaces and ventilator equipment, making ICU patients highly exposed.

5.4 Antibiotics resistance pattern among culture isolates associated with VAP.

The antimicrobial resistance from this study at Muhimbili revealed significant resistance among VAP-associated bacterial isolates, particularly Gram-negative pathogens. *Acinetobacter spp.* exhibited the most alarming pattern, showing 100% resistance to aminoglycosides, sulfonamides, and fluoroquinolones, and 83.3% resistance to beta-lactams and cephalosporins, while maintaining limited susceptibility to carbapenems (16.7%). Similarly, *E. coli* showed high resistance to TMP-SMX (90%) and gentamicin (80%), with moderate resistance to beta-lactams, cephalosporins, and fluoroquinolones (60–80%). These findings mirror trends reported in Ethiopia and Kenya, where resistance among Gram-negative ICU pathogens exceeded 70% for key antibiotic classes due to empirical treatment and lack of routine susceptibility testing[9,26]. Similar findings were observed on INICC (international Nosocomial Infection Control Consortium) report involving 45 countries, with *Acinetobacter spp* recorded average resistance rate of over 92% on the comparable antibiotics[21].

Multidrug resistance was prevalent in over 70% of *E. coli*, *Klebsiella spp.*, and *P. aeruginosa* isolates, while all *Acinetobacter spp.* isolates were MDR. The overall average rate of MDR in this study is slightly higher (over 69%) than that reported on Global antimicrobial resistance and use surveillance system (GLASS) report (2022), suggesting intensified selective pressure in

Tertiary ICUs in Dar es salaam possibly due to prolonged empirical antibiotic use and limited IPC enforcement[34].

Importantly, these findings raise concern in the context of the Tanzania Standard Treatment Guidelines (STG, 2022), which currently recommend ciprofloxacin or a combination of ceftriaxone plus sulbactam as first-line therapy for hospital-acquired pneumonia (HAP), a category under which ventilator-associated pneumonia (VAP) falls. Given the high level of resistance observed to fluoroquinolones and cephalosporins among the predominant Gram-negative isolates, empirical use of these regimens may offer limited clinical benefit in critically ill patients.

CHAPTER SIX

6.0 STUDY STRENGTHS AND LIMITATIONS.

6.1 Strengths of the Study

This study had several notable strengths. Firstly, the multicenter design involving three major national referral hospitals (MNH, JKCI, and MOI) enhances the generalizability of findings within tertiary care settings in Dar es Salaam. Secondly, the data collection process was comprehensive, incorporating clinical, hematological, radiological, and microbiological information. This allowed for a detailed analysis of ventilator-associated pneumonia (VAP) pathogens and their resistance patterns. The use of standardized diagnostic criteria, such as the Clinical Pulmonary Infection Score (CPIS), further ensured the reliability and comparability of results with international studies. Additionally, the application of both descriptive and inferential statistical methods, including bivariate and multivariate logistic regression, strengthened the validity of observed associations.

6.2 Limitations and Mitigation Strategies

Despite its strengths, the study had several limitations. The relatively small sample size may have limited the statistical power, especially in multivariate analysis, potentially obscuring weaker associations. To address this, future studies should consider a longer data collection period or multi-site collaboration to increase the sample size. Furthermore, the study was conducted exclusively in urban, tertiary-level hospitals, which may not reflect conditions in rural or lower-tier health facilities. Expanding future research to include regional and district hospitals would improve external validity.

As a cross-sectional study, it captured data at a single time point, preventing assessment of causality or clinical outcomes such as progression, mortality, or length of ICU stay; which

might have missed late-onset VAP or post-ICU outcomes. To overcome this, future research should adopt a longitudinal or cohort design.

Moreover, prior antibiotic use may have suppressed bacterial growth in cultures, leading to underestimation of certain pathogens. The study also lacked molecular characterization of resistance mechanisms (e.g., ESBL or carbapenemase genes), and future studies should consider incorporating PCR or other molecular techniques. Addressing these limitations in future research through larger, multicenter cohort studies with follow-up would enhance the robustness and clinical relevance of findings.

CHAPTER SEVEN

7.0 CONCLUSION

This study highlights a significant burden of ventilator-associated pneumonia (VAP) among ICU patients at Muhimbili, with a high prevalence of multidrug-resistant (MDR) pathogens. The most commonly isolated organisms were *Pseudomonas aeruginosa*, *Klebsiella pneumoniae*, *E. coli*, *Acinetobacter spp.*, and *Staphylococcus aureus*, many of which demonstrated substantial resistance to key antibiotic classes. Notably, *Acinetobacter spp.* and *S. aureus* exhibited the highest levels of resistance, raising concern for possible extensive drug resistance. Age and comorbidities burden showed association with VAP, reinforcing their role as key vulnerability factors.

7.1 RECOMMENDATIONS

1. Meropenem as the Preferred Optional Agent for VAP.

Given the susceptibility profile observed in this study, meropenem emerges as the most effective treatment option for patients diagnosed with VAP while other commonly administered antibiotics showed markedly reduced effectiveness across most isolates. These findings suggest that empirical initiation of meropenem could provide optimal coverage for the majority of VAP pathogens encountered in this ICU population in tertiary hospitals, however caution should be exercised before considering meropenem as an optional treatment for VAP due to the fact that the present findings, derived from a relatively small sample size and limited study duration, may not fully represent the broader resistance patterns in other ICUs or healthcare settings. Empirical use, however, should be guided by local antibiograms and accompanied by culture-based de-escalation to prevent overuse and further emergence of carbapenem resistance.

2. Enhance Routine Microbiological Surveillance

Majority of culture isolates were MDR calls for regular surveillance of ICU-acquired infections and resistance patterns should be institutionalized to guide clinical decision-making and policy development. This will support early pathogen detection and appropriate treatment selection.

3. Recommended Areas for Future Research

- Longitudinal and multicenter studies on VAP incidence and risk factors

  Future research should include larger multicenter cohorts to confirm these associations (male sex, comorbidities) and explore additional patient- and ICU-level factors (e.g., ventilator settings, sedation protocols, and staffing ratios
- Clinical trials comparing empiric antibiotic regimens

  Given that meropenem showed the highest coverage in this cohort, randomized controlled trials or prospective studies could compare meropenem to other empiric regimens (e.g., piperacillin-tazobactam) in terms of clinical outcomes, resistance development, and cost-effectiveness.

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APPENDICES

Appendix i: Consent Form (English Version)

Title: VENTILATOR ASSOCIATED PNEUMONIA AMONG ADULT PATIENTS IN INTENSIVE CARE UNITS AT MUHIMBILI

I, Dr. Michael Gilya, a resident in the department of Internal medicine at Kairuki University, would like to conduct the named study above as necessary requirements for fulfilment of my post graduate studies.

Your participation is required in order to acquire necessary information regarding your patient health to be used as data in this study.

The study intends to determine prevalence and antibiotics susceptibility of bacteria isolates linked with ventilator associated pneumonia at the Muhimbili. Findings from this study are expected to contribute to improved diagnostic protocols, timely interventions, and better patient outcomes.

Those adults who have been on invasive mechanical ventilator for ≥ 48 hours and meet the inclusion criteria will be recruited into the study and data will be collected by using a structure data collection form, which will include their social demographic characteristics and physical examination.

Blood tests for arterial blood gases and full blood picture will be taken, there will be a slight pain on puncture for blood sample collection.

Laboratory results will not be released to any unauthorized person.

The participant will not be asked any fee/money and will be free to withdraw at any time during the study.

People to contact in case of questions or problems.

Prof Y. Mgonda, chairperson of department of Internal Medicine

Director of Post Graduate Studies and Research Institute of HKMU

I……..…….have read/been told of the contents of this form and understood its meaning. Hence, I agree to participate in this study.

Signature ……... (Participant), Date……...

Signature……. (Researcher), Date……...

Appendix ii: Fomu Ya Ridhaa (Toleo La Kiswahili)

PNEUMONIA INAYOHUSIANA NA MASHINE YA KUPUMULIA (VENTILATOR) MIONGONI MWA WAGONJWA WATU WAZIMA KATIKA VYUMBA VYA UANGALIZI MAALUMU (ICU) KATIKA HOSPITALI ZA RUFAA ZA MUHIMBILI

Mimi, Dkt. Michael Gilya, mwanafunzi wa shahada ya uzamili ya magonjwa ya ndani katika Chuo Kikuu cha Kairuki. Ninafanya utafiti kuhusu pneumonia inayohusiana na mashine ya kupumulia miongoni mwa wagonjwa watu wazima katika vyumba vya uangalizi maalumu (icu) katika hospitali za rufaa za muhimbili. Utafiti huu ni kati ya vigezo muhimu vinavyohitajika ili niweze kukamilisha masomo yangu ya shahada ya uzamili

Ushiriki wako unahitajika ili kupata taarifa muhimu zinazohusiana na afya ya mgonjwa wako zitakazotumika kama data katika utafiti huu.

Lengo la utafiti ni kubaini kiwango cha maambukizi na usugu wa bakteria kwa dawa za antibiotiki, wanaohusiana na pneumonia inayotokana na matumizi ya mashine ya kupumulia katika Hospitali za rufaa za Muhimbili. Matokeo ya utafiti huu yanatarajiwa kuchangia maboresho katika taratibu za uchunguzi, matibabu sahihi ndani ya muda mfupi, na matokeo bora kwa wagonjwa.

Wagonjwa watu wazima waliowekwa kwenye ventilator kwa masaa 48 au zaidi na wanaokidhi vigezo vya kushiriki watajumuishwa katika utafiti huu. Data zitakusanywa kwa kutumia fomu maalum ya ukusanyaji wa takwimu, ambayo itajumuisha taarifa za kijamii na kimwili za washiriki.

Vipimo vya damu kwa ajili ya gesi ya damu ya ateri na picha kamili ya damu vitachukuliwa. Kunaweza kuwa na maumivu kidogo wakati wa kuchukuliwa kwa sampuli ya damu.

Majibu ya vipimo ya wagonjwa hayatapelekwa kwa mtu yeyote ambaye hajaidhinishwa kuyapata.

Mshiriki hatatakiwa kulipa gharama yoyote na atakuwa huru kujiondoa wakati wowote katika kipindi cha utafiti.

Watu wa Kuwasiliana Nao Endapo Kuna Maswali au Matatizo:

Prof. Y. Mgonda, Mwenyekiti wa Idara ya Tiba ya Ndani

Mkurugenzi wa Masomo ya Uzamili na Taasisi ya Utafiti ya HKMU

Mimi …… nimeelezwa/nimesoma yaliyomo kwenye fomu hii na nimeelewa maana yake. Hivyo, nakubali kushiriki katika utafiti huu.

Sahihi ya Mshiriki: …….. Tarehe: ……

Sahihi ya Mtafiti: …….. Tarehe: ……

Appendix iii: Data extraction form (English version)

Ventilator associated pneumonia among adult patients in intensive care unit at Muhimbili.

A: **Socio-demographic information**

1. Questionnaire No ……..
2. Health facility……
3. Participant's initials……
4. Date of Birth (Age)……
5. Gender Male ☐ Female ☐
6. Marital status Married ☐ not married ☐ widowed ☐ Divorced ☐
7. Residence……
8. Date of intubation……
9. Place where intubation done……
10. Date of study enrollment……

B: Clinical information

11. Reason for Mechanical Ventilation (Primary Diagnosis)
    - Respiratory Failure
    - Sepsis
    - Post-Surgical Complications
    - Anaesthetic Complications
    - Trauma
    - Neurological Impairment
    - cardiovascular condition
    - Others (Specify)……

12. underlying comorbidities comorbidities (Select all that apply)

- Diabetes Mellitus
- Hypertension
- Chronic Obstructive Pulmonary Disease (COPD)
- Chronic Kidney Disease
- Others (Specify)…….

13. History of smoking? Yes ☐ No ☐

14. History alcohol

15. Is he/he on any antibiotics?

Yes ☐ No ☐

16. If yes (Qn 15) specify the antibiotic(s) used

……

……

17. If YES (Qn 15) for how long? less than 24 hours ☐re or ≥48 hours ☐

18. Did you change or add new antibiotics in the past 48 hours? Yes ☐No ☐

19. Is he/she clinically suspected VAP patient? Yes ☐ No ☐

20. if yes (Qn 19), PaO_2/FiO_2 ration ≤ 240mmHg ☐or ≥240mmHg ☐

21. If yes (Qn 19) chest x-ray done? Yes ☐ No ☐

22. If yes (Qn 21) CXR score is 0 ☐ 1 ☐ 2 ☐

23. Tracheal aspirate collected?.....date of collection……

24. Microbial identified? GNB ☐ GPB ☐ Mixed ☐ Negative ☐

25. Number of different isolates? One☐ Two☐ three or more ☐

26. Name the microorganism isolated on culture…….

27. Isolated of (Qn 23) identified as susceptible ☐ resistant ☐ intermediate ☐

28. Antibiotic sensitivity pattern (among commonly used antibiotics in ICU at MNH) for (each pathogen isolated)

Pathogen(s)	**Antibiotic tested**	**Sensitivity**	**Resistant**	**intermediate**

Appendex iv: Dodoso (Kiswahili)

Pneumonia Inayohusiana na Ventilator Miongoni mwa Wagonjwa Watu Wazima Katika Vyumba vya Uangalizi Maalumu Katika Hospitali za rufaa ya juu zilizopo Muhimbili.

A: **Taarifa za Kijamii na Kidemografia**

1. Nambari ya dodoso……..
2. Eneo la utafiti…….
3. Herufi za mwanzo za majina…….
4. Umri (Miaka)
5. Jinsia Mme ☐ mke ☐
6. Hali ya ndoa: Ameoa/ameolewa ☐ Hajaolewa/hajaoa ☐ mjane ☐ meachika ☐
7. Makazi: ……
8. Tarehe ya kuwekewa ventilator: ……
9. Mahali ambapo ventilator iliwekwa: ……..
10. Tarehe ya kujumuishwa katika utafiti: …….

B: Taarifa za Kimatibabu

11. Sababu ya kuwekwa kwenye Ventilator (ugonjwa sababishi wa Awali):
    - Kushindwa Kupumua (Respiratory Failure)
    - Maambukizi makali ya vimelea ya mwili
    - Matatizo baada ya upasuaji
    - Matatizo ya anesthesia
    - Majeraha (Trauma)
    - Uharibifu wa mfumo wa neva
    - Hali ya moyo na mishipa
    - Nyinginezo (Taja)…….

12. Magonjwa ya Msingi Yanayoshirikiana (Chagua yote yanayohusika)

- Kisukari (Diabetes Mellitus)
- Shinikizo la damu (Hypertension)
- Ugonjwa sugu wa kuziba kwa mapafu (COPD)
- Ugonjwa sugu wa figo
- Nyinginezo (Taja)……..

13. uvutaji wa sigara? ndio ☐ hapana ☐

14. Historia ya unywaji pombe? Ndio ☐ Hapana ☐

15. Anatumia dawa za viuavijasumu (antibiotics)?

ndio ☐ hapana ☐

16. Ikiwa ndiyo (Swali la 15), taja dawa zinazotumika

……

……

17. Ikiwa ndiyo (Swali la 15), ametumia kwa muda gani?

Chini ya masaa 24 ☐ zaidiya masaa 48 ☐

18. Je, imebadilishwa au kuongeza dawa mpya za viuavijasumu ndani ya masaa 48 yaliyopita?

Ndio ☐ Hapana ☐

19. Je mgonjwa ni mhisiwa wa pneumonia ihusianayo na ventileta kwa kutumia CPIS ?

Ndio ☐ Hapana ☐

20. Ikiwa ndio (swali 19), uwiano wa $PaO_2/FiO_2 \leq 240mmHg$ ☐ or $\geq 240mmHg$ ☐

21. kama ndio (swal 19) x-ray ya kifua ilifanyika? Ndio ☐ hapana ☐

22. Ikiwa ndio (swal19) alama za x-ray za kifua? 0 ☐ 1 ☐ 2 ☐

23. Sampuli ya majimaji wa trachea imekusanywa.?..... tarehe……

24. Uchunguzi wa vimelea umefanyika? GNB ☐ GPB ☐

Mchanganyiko ☐ hakuna vimelea vilivyoonekana ☐

25. Idadi ya vimelea tofauti vilivyopatikana? Moja ☐ mbili ☐ tatu au zaidi ☐

26. Taja Kimelea/vimelea vilivyoota kwenye Sahani ya kuoteshea……

27. Uchunguzi wa vimelea katika ustahimivu wa dawa (antibiotics) umeonesha?

Kinahimili dawa ☐ Kinasikia dawa ☐ kiwango cha kati ☐

28. Mpangilio wa unyeti wa viuavijasumu (kwa dawa zinazotumika mara kwa mara ICU za muhimbili) kwa kila kimelea kilichoota.

kimelea	**Dawa iliyojaribiwa**	**Kinasikia dawa**	**Kinahimili dawa**	**Kiwango cha kati**

Appendix v: Modified Clinical Pulmonary Infection Score (CPIS) tool

PARAMETERS	**SCORES**	**POINTS**	
Temperature ◦c	≥36.5 and ≤ 38.4	0	
	≥38.5 and ≤38.9	1	
	≥ 39 or ≤ 36.4	2	
Total white blood cell count	≥4.0x10^9 /L and ≤11x10^9 /L	0	
	<4.0x10^9 /L or >11x10^9 /L	1	
	<4.0x10^9 /L or > 11x10^9 /L & band forms ≥ 50%	2	
Tracheal secretions	scanty	0	
	copious	1	
	copious + pus like	2	
PaO2/FiO2 ratio (mmHg)	>240 or ARDS	0	
	-	-	
	≤ 240 or no ARDS	2	
Lung film	no infiltrate	0	
	diffuse infiltrate	1	
	localized infiltrate	2	
Culture of endotracheal aspirate	Few quantities or no growth	0	
	moderate or heavy growth	1	
	Presence of the same pathogen on the gram stain	2	
Calculated total Clinical pulmonary Infection score (CPIS score)			

Appendix vi: AST Break points for common isolates - CLSI (2023) guidelines

Antimicrobial Agent	Enterobacterales (S/I/R)	P. aeruginosa (S/I/R)	Acinetobacter spp (S/I/R)	Staphylococcus species (S/I/R)
Ampicillin 10µg	≥17 / 14-16 / ≤13	-	-	-
Amikacin 30µg	≥20 / 17-19 / ≤16	-	-	-
Amoxicillin-Clavulanate (AMC/AUG) 20/10µg	≥18 / 14-17 / ≤13	-	-	-
Piperacillin/Tazobactam (TZP) 100/10µg	≥25 / - / ≤20	-	-	-
Cefepime 30µg	≥22 / - / ≤20	≥22 / 18-21 / ≤17	≥21 / 18-20 / ≤17	-
Cefotaxime 30µg or Ceftriaxone 30µg	≥25 / - / ≤20	≥18 / 15-17 / ≤14	≥18 / 15-17 / ≤14	-
Cefoxitin 30µg	≥23 / 20-22 / ≤19	-	-	-
(S. aureus & S. lugdunensis)	≥23 / 20-22 / ≤19	-	-	≥23 / 20-22 / ≤19
(S. epidermidis)	≥18 / 15-17 / ≤14	-	-	≥18 / 15-17 / ≤14

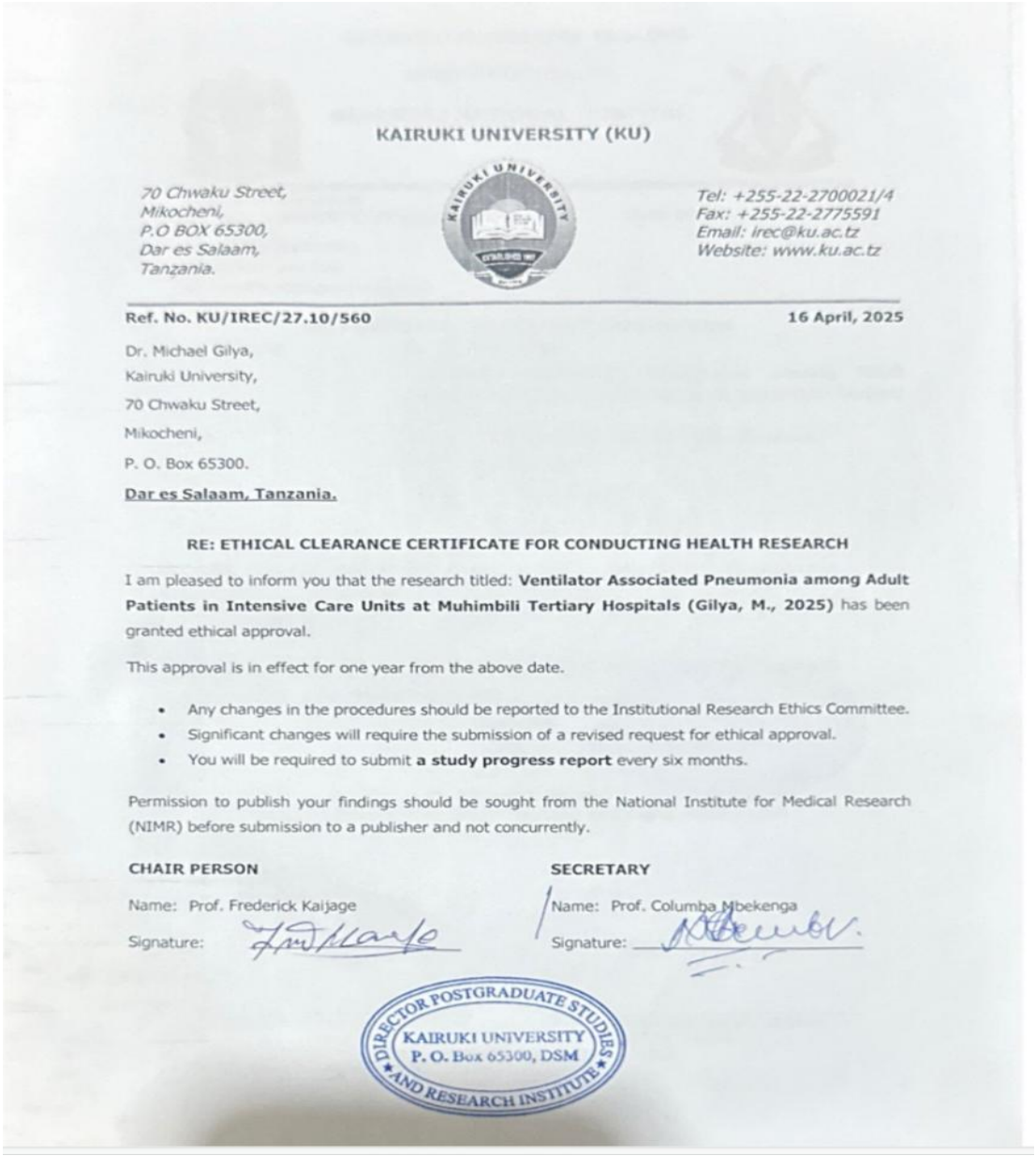
Antimicrobial Agent	Enterobacterales (S/I/R)	P. aeruginosa (S/I/R)	Acinetobacter spp (S/I/R)	Staphylococcus species (S/I/R)
Ceftazidime 30µg	≥21 / 18-20 / ≤17	≥22 / 18-21 / ≤16	≥18 / 15-17 / ≤14	-
Imipenem 10µg or Meropenem 10µg	≥23 / 20-22 / ≤19	≥22 / 19-21 / ≤18	≥22 / 19-21 / ≤18	-
Gentamycin 10µg or Tobramycin 10µg	≥23 / 20-22 / ≤19	≥19 / 16-18 / ≤15	≥18 / 15-17 / ≤14	-
Amikacin 30µg (P. aeruginosa in Urine only)	≥20 / 17-19 / ≤16	≥19 / 16-18 / ≤15	≥15 / 13-14 / ≤12	-
Azithromycin 15µg	≥13 / - / ≤12	-	-	-
Tetracycline 30µg or Doxycycline 30µg	≥16 / 11-15 / ≤10	-	-	-
Ciprofloxacin 5µg	≥15 / 12-14 / ≤9	≥19 / 16-18 / ≤15	≥18 / 15-17 / ≤14	≥18 / 15-17 / ≤14
Nalidixic acid 30µg (For Urine Only)	≥17 / 14-16 / ≤13	≥19 / 16-20 / ≤15	≥21 / 16-20 / ≤15	-
Trimethoprim/Sulfamethoxazole 1.25/23.75µg	≥16 / 11-15 / ≤10	-	≥16 / 11-15 / ≤10	-
Chloramphenicol 30µg (Not for Urine)	≥18 / 13-17 / ≤12	-	≥18 / 13-17 / ≤12	-
Nitrofurantoin 30µg (For Urine Only)	≥17 / 15-16 / ≤14	-	≥17 / 15-16 / ≤14	-

Antimicrobial Agent	Enterobacterales (S/I/R)	P. aeruginosa (S/I/R)	Acinetobacter spp (S/I/R)	Staphylococcus species (S/I/R)
Clindamycin (DA) 2µg (Not reported in Urine)	-	-	-	≥15 / 13-14 / ≤12
Penicillin 10 units	-	-	-	≥17 / 15-16 / ≤14
Piperacillin 100µg	-	≥22 / 18-21 / ≤16	≥18 / 15-17 / ≤14	-
Erythromycin 15µg (Not routinely reported)	-	-	-	≥23 / 14-22 / ≤13

S = Susceptible, I = Intermediate, R = Resistant

Note: Some breakpoints are specific for certain sample types such as urine or blood only.

Appendix vii: Kairuki University/Institution Review Ethical Committee (IREC); Ethical Clearance certificate for conducting health research.



KAIRUKI UNIVERSITY (KU)

70 Chwaku Street,
Mikocheni,
P.O BOX 65300,
Dar es Salaam,
Tanzania.

Tel: +255-22-2700021/4
Fax: +255-22-2775591
Email: irec@ku.ac.tz
Website: www.ku.ac.tz

Ref. No. KU/IREC/27.10/560 **16 April, 2025**

Dr. Michael Gilya,
Kairuki University,
70 Chwaku Street,
Mikocheni,
P. O. Box 65300.
Dar es Salaam, Tanzania.

RE: ETHICAL CLEARANCE CERTIFICATE FOR CONDUCTING HEALTH RESEARCH

I am pleased to inform you that the research titled: **Ventilator Associated Pneumonia among Adult Patients in Intensive Care Units at Muhimbili Tertiary Hospitals (Gilya, M., 2025)** has been granted ethical approval.

This approval is in effect for one year from the above date.

- Any changes in the procedures should be reported to the Institutional Research Ethics Committee.
- Significant changes will require the submission of a revised request for ethical approval.
- You will be required to submit **a study progress report** every six months.

Permission to publish your findings should be sought from the National Institute for Medical Research (NIMR) before submission to a publisher and not concurrently.

CHAIR PERSON

Name: Prof. Frederick Kaijage

Signature:

SECRETARY

Name: Prof. Columba Mbekenga

Signature:

DIRECTOR POSTGRADUATE STUDIES AND RESEARCH INSTITUTE
KAIRUKI UNIVERSITY
P. O. Box 65300, DSM

Appendix viii: Approval to collect data at Muhimbili National Hospital (MNH)

THE UNITED REPUBLIC OF TANZANIA

MINISTRY OF HEALTH

MUHIMBILI NATIONAL HOSPITAL

In reply please quote;
Ref. No.: MNH/CRTCU/Perm/2025/163 Date: 8th May, 2025

Head of Department,
Intensive Care Unit,
Muhimbili National Hospital

RE: PERMISSION TO COLLECT DATA AT MNH

Name Student	**Dr. Michael Gilya**
Title	**"Ventilator Associated Pneumonia Among Adult Patients In Intensive Care Units At Muhimbili Tertiary Hospitals"**
Institution	Kairuki University Of Health and Allied Sciences
Supervisor	Prof Yasin Mgonda
Co- Supervisor	Dr. Ronald Mramba (MNH)
Period	12th May, 2025 to 12th July, 2025

Approval has been granted to the above principal investigators to collect data at MNH. Dissemination of study findings at MNH shall be overseen by **Dr. Ronald Mramba (MNH)** supervisor.

Kindly ensure the named principal investigator abide to the ethical principles and other conditions of the research approval.

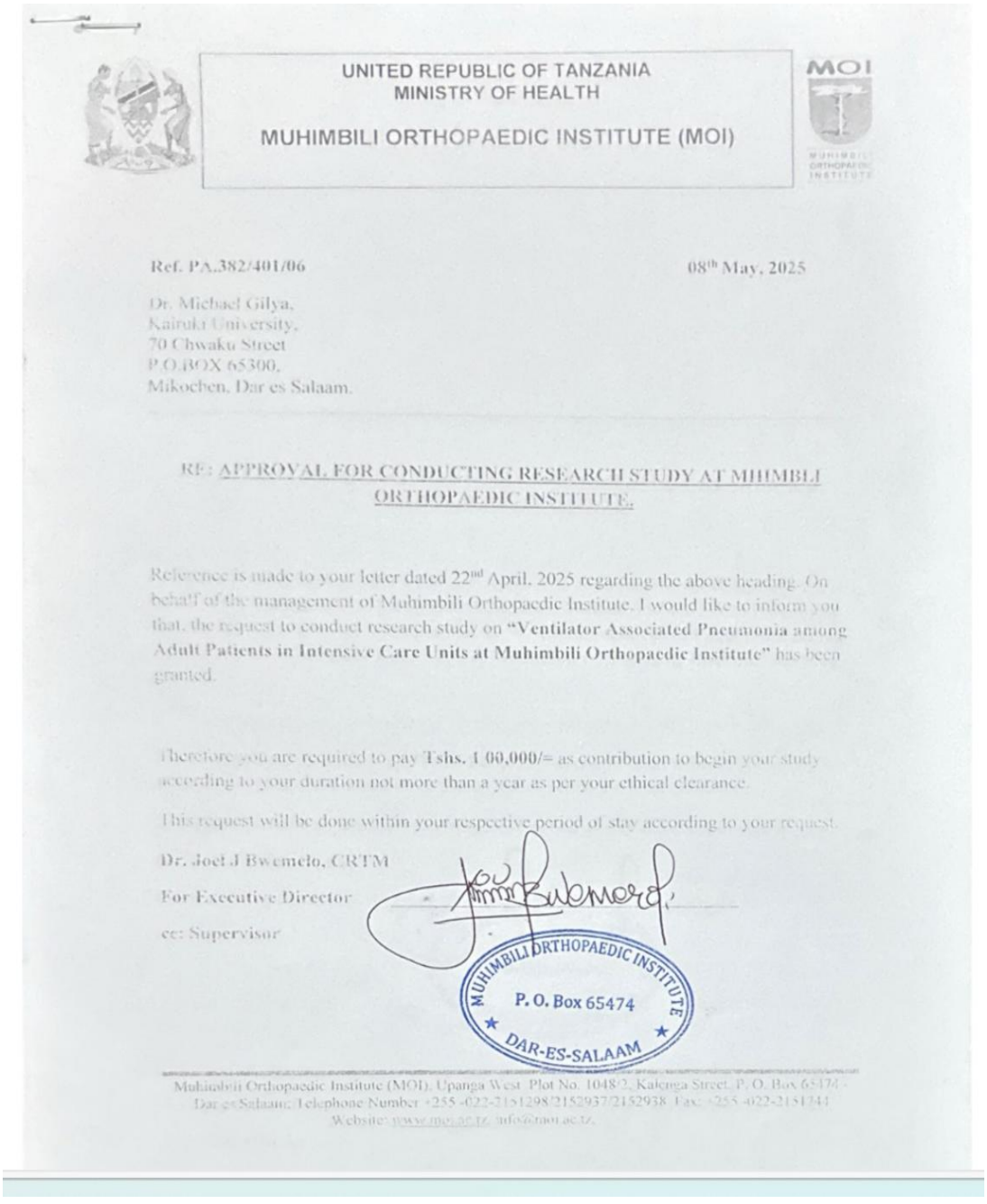
Sincerely,

HEAD, TEACHING, RESEARCH & CONSULTANCY UNIT * P.O. Box 65000 DAR-ES-SALAAM * MUHIMBILI NATIONAL HOSPITAL *

Dr. Robert D. Moshiro
Head of Clinical Research, Training and Consultancy Unit

c:c DMS,
c:c Dr. Ronald Mramba

Appendix ix: Approval for conducting research study at Muhimbili Orthopedic Institute (MOI)



UNITED REPUBLIC OF TANZANIA
MINISTRY OF HEALTH

MUHIMBILI ORTHOPAEDIC INSTITUTE (MOI)

Ref. PA.382/401/06

08th May, 2025

Dr. Michael Gilya,
Kairuki University,
70 Chwaku Street
P.O.BOX 65300,
Mikocheni, Dar es Salaam.

RE: APPROVAL FOR CONDUCTING RESEARCH STUDY AT MHIMBILI ORTHOPAEDIC INSTITUTE.

Reference is made to your letter dated 22nd April, 2025 regarding the above heading. On behalf of the management of Muhimbili Orthopaedic Institute, I would like to inform you that, the request to conduct research study on **"Ventilator Associated Pneumonia among Adult Patients in Intensive Care Units at Muhimbili Orthopaedic Institute"** has been granted.

Therefore you are required to pay **Tshs. 100,000/=** as contribution to begin your study according to your duration not more than a year as per your ethical clearance.

This request will be done within your respective period of stay according to your request.

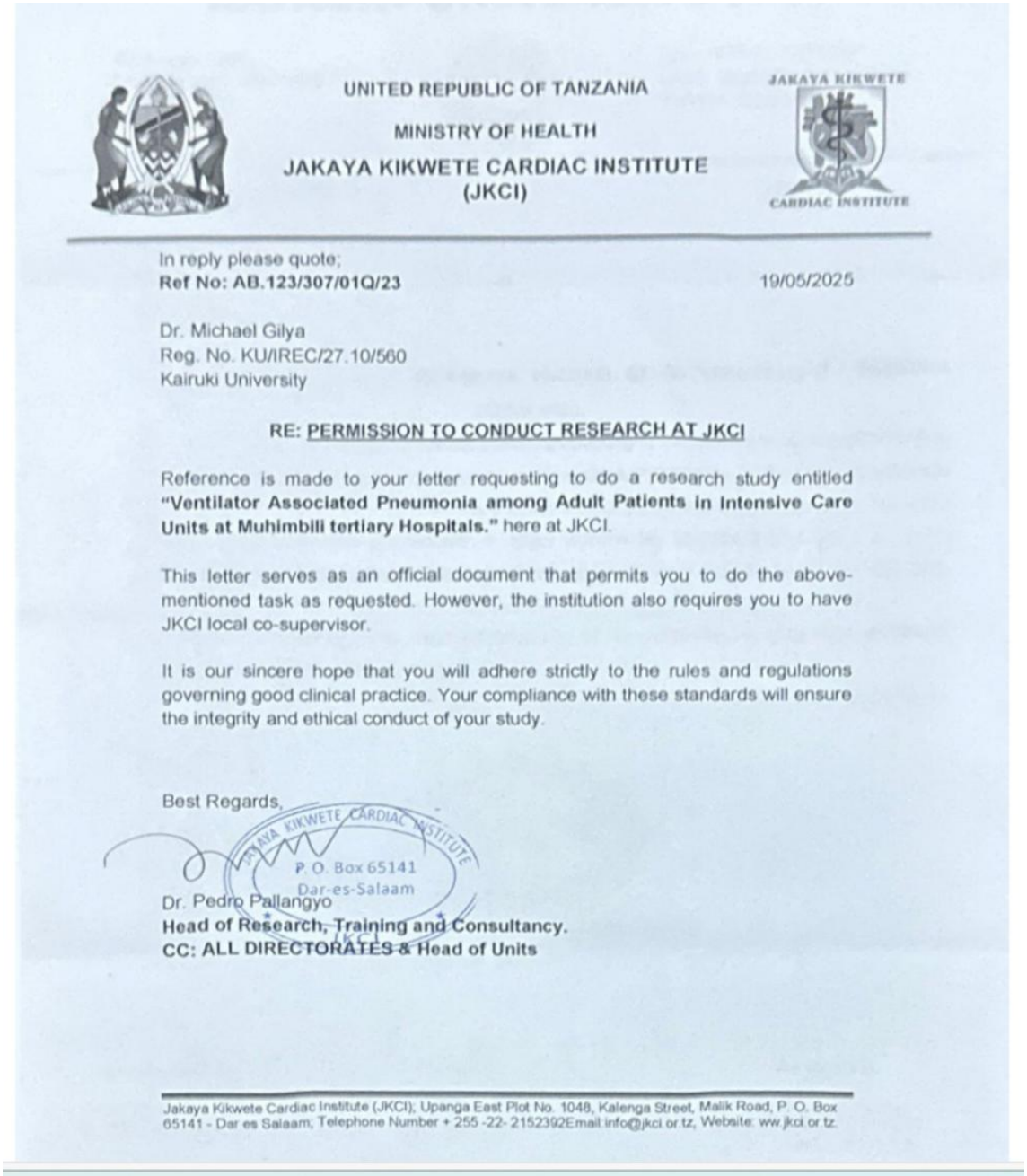
Dr. Joel J Bwemelo, CRTM
For Executive Director

cc: Supervisor

MUHIMBILI ORTHOPAEDIC INSTITUTE
P. O. Box 65474
DAR-ES-SALAAM

Muhimbili Orthopaedic Institute (MOI), Upanga West, Plot No. 1048/2, Kalenga Street, P. O. Box 65474, Dar es Salaam, Telephone Number +255-022-2151298/2152937/2152938, Fax: +255-022-2151341
Website: www.moi.ac.tz, info@moi.ac.tz

Appendix x: Approval for conducting research study at Jakaya Kikwete Cardiac Institute (JKCI)



UNITED REPUBLIC OF TANZANIA

MINISTRY OF HEALTH

JAKAYA KIKWETE CARDIAC INSTITUTE (JKCI)

JAKAYA KIKWETE CARDIAC INSTITUTE

In reply please quote;
Ref No: AB.123/307/01Q/23 19/05/2025

Dr. Michael Gilya
Reg. No. KU/IREC/27.10/560
Kairuki University

RE: PERMISSION TO CONDUCT RESEARCH AT JKCI

Reference is made to your letter requesting to do a research study entitled **"Ventilator Associated Pneumonia among Adult Patients in Intensive Care Units at Muhimbili tertiary Hospitals."** here at JKCI.

This letter serves as an official document that permits you to do the above-mentioned task as requested. However, the institution also requires you to have JKCI local co-supervisor.

It is our sincere hope that you will adhere strictly to the rules and regulations governing good clinical practice. Your compliance with these standards will ensure the integrity and ethical conduct of your study.

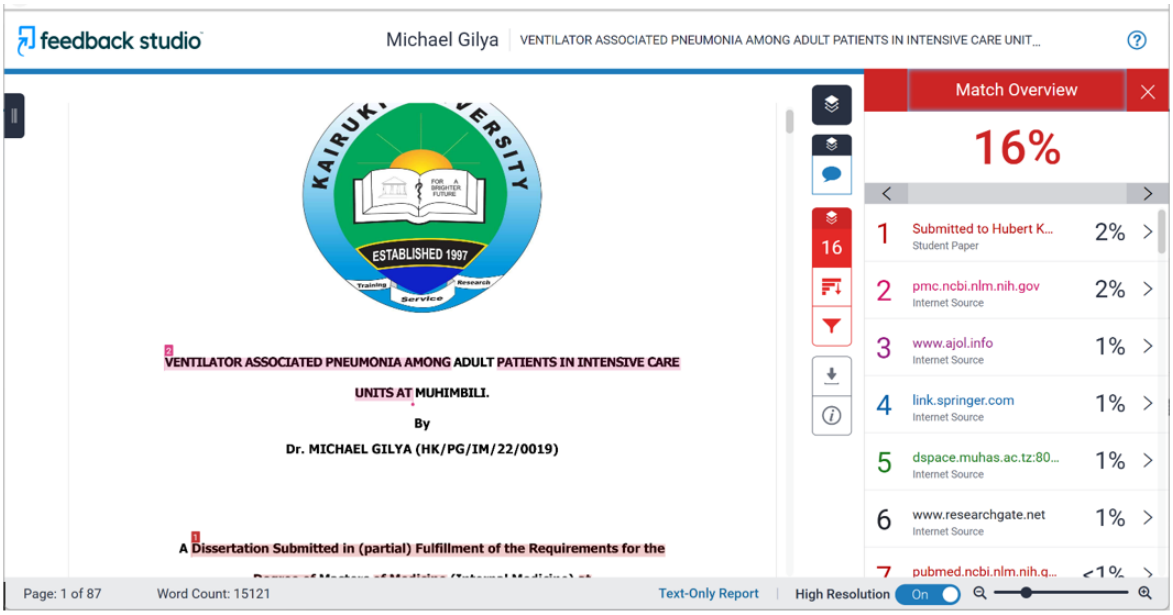
Best Regards,

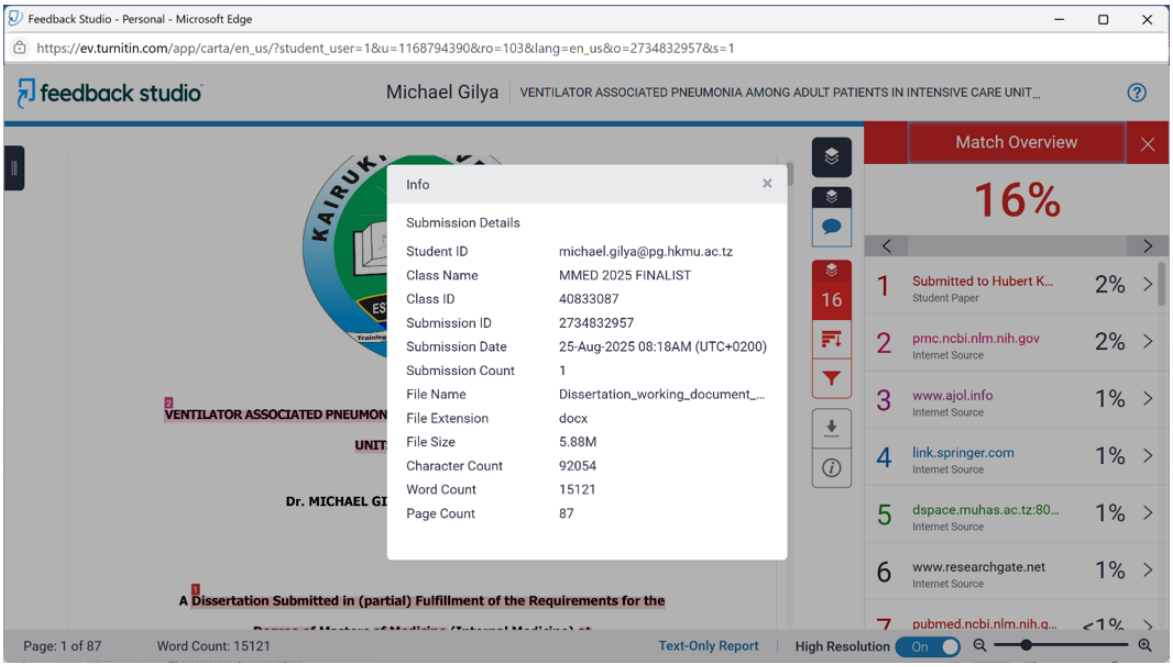
JAKAYA KIKWETE CARDIAC INSTITUTE
P. O. Box 65141
Dar-es-Salaam
JKCI

Dr. Pedro Pallangyo
Head of Research, Training and Consultancy.
CC: ALL DIRECTORATES & Head of Units

Jakaya Kikwete Cardiac Institute (JKCI); Upanga East Plot No. 1048, Kalenga Street, Malik Road, P. O. Box 65141 - Dar es Salaam; Telephone Number + 255 -22- 2152392Email info@jkci.or.tz, Website: ww.jkci.or.tz.

Appendix xi: Turnitin Plagiarism report





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Assignment title:	Research Proposal
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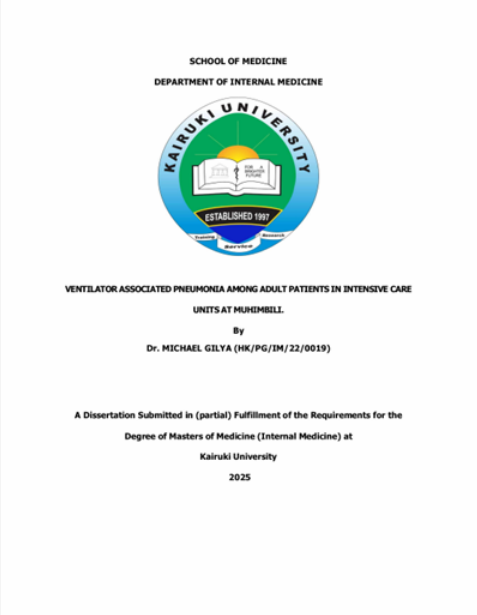
File name:	Dissertation_working_document_2408_latest.docx
File size:	5.88M
Page count:	87
Word count:	15,121
Character count:	92,054
Submission date:	25-Aug-2025 08:18AM (UTC+0200)
Submission ID:	2734832957



SCHOOL OF MEDICINE

DEPARTMENT OF INTERNAL MEDICINE

VENTILATOR ASSOCIATED PNEUMONIA AMONG ADULT PATIENTS IN INTENSIVE CARE UNITS AT MUHIMBILI.

By

Dr. MICHAEL GILYA (HK/PG/IM/22/0019)

A Dissertation Submitted in (partial) Fulfillment of the Requirements for the Degree of Masters of Medicine (Internal Medicine) at Kairuki University

2025