PREVALENCE, DETERMINANTS, AND OUTCOMES OF PROLONGED MECHANICAL VENTILATION IN PATIENTS ADMITTED INTO THE INTENSIVE CARE UNIT AT TENWEK HOSPITAL, KENYA

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A Thesis Submitted to the Institute of Postgraduate Studies of Kabarak University in Partial Fulfillment of the Requirement for the Award of Master of Science (Critical Care Nursing) Degree

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DECLARATION

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The thesis entitled "**Prevalence, Determinants, and Outcomes of Prolonged Mechanical Ventilation in Patients Admitted into the Intensive Care Unit at Tenwek Hospital, Kenya,"** written by **Mourine Achieng Ooro**, is presented to the Institute of Postgraduate Studies of Kabarak University. We have reviewed the research thesis and recommend that it be accepted in partial fulfillment of the requirements for the award of the degree of Master of Science in critical care nursing.

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DEDICATION

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ABSTRACT

In intensive care units (ICUs) worldwide, prolonged mechanical ventilation (PMV) affects approximately 30% of mechanically ventilated patients, exacting a heavy toll through heightened morbidity, mortality, and escalating healthcare costs. Yet, despite advances in critical care, the predictors and outcomes of PMV remain poorly understood in low-resource settings, where resource constraints amplify these challenges. This study sought to ascertain the prevalence, determinants, and consequences of PMV among mechanically ventilated adult ICU patients at Tenwek Hospital, Kenya. A retrospective cohort design was employed to review the medical records of adult ICU patients who required mechanical ventilation for more than 7 consecutive days from January to December 2024. Data collection encompassed three key domains: ventilatory parameters, patient–ventilator interactions, and clinical status, supplemented by pertinent laboratory and imaging findings. Descriptive statistics characterised the cohort, while inferential analyses—comprising multivariable logistic regression for PMV predictors and Cox proportional hazards models for time to extubation—identified associations at the $p < 0.05$ significance level. Variable selection was guided by a conceptual framework, with adjusted odds ratios (ORs) and 95% confidence intervals (CIs) reported; model robustness was maintained by ensuring at least 10 events per predictor. Of 173 mechanically ventilated adults, 72.3% experienced PMV (>7 days). Multivariable logistic regression pinpointed acute respiratory distress syndrome (ARDS; adjusted OR = 5.25, 95% CI: 2.35–11.75) and chronic obstructive pulmonary disease (COPD; adjusted OR = 5.28, 95% CI: 2.38–11.73) as the foremost predictors, trailed by pneumonia (adjusted OR = 1.82, 95% CI: 0.80–4.14) and sepsis (adjusted OR = 1.56, 95% CI: 0.69–3.52). Daily sedation vacations curtailed PMV odds by 81% (adjusted OR = 0.19, 95% CI: 0.08–0.46), while early mobility protocols diminished them by 37% (adjusted OR = 0.63, 95% CI: 0.28–1.42). Cox analysis revealed an ICU mortality rate of 69.9%, with moderate disease severity associated with delayed extubation (hazard ratio [HR] = 0.53, 95% CI: 0.30–0.93, $p = 0.025$). In conclusion, PMV imposes a formidable burden in this Kenyan ICU context, driven by respiratory pathologies and modifiable management gaps. We recommend embedding structured daily sedation interruptions and early mobility protocols into routine ICU practice to shorten ventilation duration, reduce resource strain, and improve patient outcomes in similar low-resource environments.

Keywords: *Prolonged Mechanical Ventilation, ICU Patients, Demographic Risk Factors, Clinical Risk Factors, Low-Resource Settings*

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LIST OF ABBREVIATIONS AND ACRONYMS

APACHE III	Acute Physiology Age Chronic Health Evaluation III
APS	Acute Physiology Score
ARDS	Acute Respiratory Distress Syndrome
COVID-19	Coronavirus Disease of 2019
EC	Emergency Centres
ETT	Endotracheal Tube
FiO2	Fraction of inspired Oxygen
HBM	Health Belief Model
ICD	International Classification of Diseases
ICU	Intensive Care Unit
MV	Mechanical Ventilation
NAMDRC	National Association for Medical Direction of Respiratory Care
PEEP	Positive End-Expiratory Pressure
PMV	Prolonged Mechanical Ventilation

CONCEPTUAL AND OPERATIONAL DEFINITION OF TERMS

Clinical Risk Factors: In adult ICU patients at Tenwek Hospital from January to December 2024, conditions or comorbidities that indicated prolonged mechanical ventilation were considered clinical risk factors. Those factors, including ARDS, COPD, pneumonia, sepsis, heart failure, diabetes, chronic kidney disease, and severity scores (ie, APACHE II, SOFA), were obtained through a retrospective chart review and were analysed by logistic regression to associate with prolonged mechanical ventilation (odds ratios [ORs], 95% CIs).

Prevalence: Refers to the proportion (percentage) of ICU patients who experienced prolonged mechanical ventilation >7 days.

Intubation: The process of inserting a tube into the trachea to maintain an open airway.

Critical Care Unit: In this study at Tenwek Hospital, located in Bomet County, Kenya, the critical care unit is defined as ICU A and ICU B, which are six-bed and seven-bed, respectively, for the treatment of adult patients (≥18 years) with life-threatening processes and a need for mechanical ventilatory support. Units offer continuous monitoring and intensive life-saving interventions (e.g., mechanical ventilation, vasopressor therapy), with advanced nursing care to stabilise patients with diseases such as ARDS, sepsis, or pneumonia, diagnosed in medical charts from January to December 2024.

Mechanical Ventilation: Refers to using invasive ventilators to deliver positive pressure ventilation via an endotracheal tube to adult ICU patients at Tenwek Hospital. It includes settings such as tidal volume, positive end-expiratory pressure (PEEP), and fraction of inspired oxygen (FiO_2), documented in patient records between January and December 2024, for conditions like ARDS, pneumonia, or chronic obstructive pulmonary disease (COPD), with a focus on patients requiring ventilation for more than seven days.

Outcomes: Refer to the clinical consequences of prolonged mechanical ventilation among adult ICU patients at Tenwek Hospital between January and December 2024. These include ICU mortality, duration of mechanical ventilation, ICU and hospital length of stay, reintubation rates, tracheostomy performance, ventilator-associated pneumonia (VAP), and discharge status, abstracted using the PMV-DAT and analysed via Cox proportional hazards models to assess time to extubation and mortality (hazard ratios, 95% CIs).

Patient Management Practices: Refer to the clinical interventions and protocols used to manage adult ICU patients on mechanical ventilation at Tenwek Hospital between January and December 2024. These include ventilator settings (e.g., tidal volume, PEEP, FiO_2), daily sedation vacations, early mobility protocols, and weaning strategies, documented in patient records and evaluated for their impact on intubation duration using logistic regression (odds ratios, 95% CIs).

Patient: Refers to an adult (18 years or older) person admitted to the ICU at Tenwek Hospital between January and December 2024, requiring mechanical ventilation due to severe illness or injury. These patients with ARDS, sepsis, pneumonia, or multiple comorbidities (e.g., COPD, heart failure, diabetes) required advanced life support, close observation, and interventions to support organ function (documented in their medical charts).

Prolonged Mechanical Ventilation (PMV): For this study, PMV is defined as ventilatory support with an endotracheal (ET) tube for ≥21 consecutive days in adult ICU patients at Tenwek Hospital, This aligns with the international standard definition used in critical care literature, where PMV is recognised as mechanical ventilation for at least 21 days (typically ≥6 hours per day) and is associated with higher rates of complications such as ventilator-associated pneumonia (VAP) and respiratory muscle weakness.

Prolonged Intubation: For this study, prolonged intubation is operationalised as the continuous placement of an endotracheal tube (ETT) for more than seven consecutive days in adult ICU patients at Tenwek Hospital, typically in conjunction with mechanical ventilation to support respiratory failure. This duration is measured from the date of initial intubation to successful extubation or tracheostomy placement (if performed as an alternative to prolonged ETT use), as documented in patient records via the PMV-DAT tool.

Support: In this study, support refers to life-saving measures provided to adult ICU patients at Tenwek Hospital who were mechanically ventilated from January to December 2024.

Severity Tiers: Severity of illness was categorised using the APACHE II score at ICU admission: patients with scores <10 were classified as low severity (reference group), 10–19 as moderate, 20–29 as high, and ≥ 30 as very high.

CHAPTER ONE

INTRODUCTION

1.1 Background of the Study

Intubation is a procedure in which a flexible plastic tube is inserted into the patient's trachea to keep the airway open and/or assist with mechanical ventilation (breathing with the help of a machine) under certain conditions, such as when administering certain drugs to an acutely ill patient. This treatment is frequently used in the ICU settings among those patients who are suffering from respiratory failure, undergoing major surgical procedures under general anaesthesia, or having airway patency compromised by conditions such as trauma, neurological impairments, and severe infections (Russotto et al., 2022). Inadequate oxygenation or ventilation, inability to protect the airway secondary to decreased level of consciousness, planned clinical deterioration, and the requirement for prolonged artificial ventilation are the primary indications for intubation (Rubulotta et al., 2024).

A prolonged mechanical ventilation period in the Intensive Care Units (ICUs) is a burden to healthcare systems, patients, and their families at the clinical, economic, and social levels. It adds to the burden of care costs, length of stay, complications, including ventilator-associated pneumonia and respiratory muscle weakness, as well as diminished quality of life (Maes et al., 2021). It is considered for prolonged mechanical ventilation in patients with acute respiratory distress syndrome (ARDS), pneumonia, or COPD who require a prolonged ICU stay and are at risk of side effects (Lineros et al., 2023). This increases the burden on healthcare because resources are being depleted and patients require more extended hospitalisations (Moucharite et al., 2021). The symptoms that patients experience are diverse, both physical and psychological, including muscle weakness and anxiety, and significantly affect the quality of patients' lives (Vivodtzev et al., 2020). There is also the emotional and financial burden on families. For example, trends suggest that while the provision of critical care has improved, the duration of intubation remains high, suggesting that external factors and ventilator settings should be optimised to reduce the incidence of intubation complications (De Jong et al., 2022).

The care and management of critically ill patients are essential aspects of current medical and nursing practice. Klingshirn et al. (2021) noted that it is necessary to recognise the role of critical care nurses in improving the quality of mechanical ventilation (MV), minimising adverse outcomes, and promoting better patient outcomes. MV is often required in patients with visible illness for varying durations. Maes et al. (2021) noted that, while most patients requiring ventilator support use it for a short duration, approximately 30% remain on ventilation for more than seven days. Although mechanical ventilation can be life-saving, it has potential side effects and consequences (Huang et al., 2021). Invasive MV is an effective treatment for stabilising patients with respiratory failure. While it is true that MV can be life-saving, its broader implications and clinical complexities can be better understood through the theoretical frameworks (Telias et al., 2022). MV treatment is required for one-third of patients admitted to the ICU worldwide (Berhe et al., 2022).

In the United States, the number of adults requiring MV is growing, particularly among individuals aged 65 and older, with an expected 80% increase from 2000 to 2026 (de Oca et al., 2025). In developed countries, 2–3 million intensive care unit (ICU) patients undergo invasive mechanical ventilation each year, at an annual cost of 15-27 billion US dollars (Amato et al., 2015). The care of critically ill patients is becoming increasingly significant in modern medical and nursing settings (Huang et al., 2021). The burden of critical illness in low and middle-income countries (LMICs) is substantial and increasing. For example, critical illnesses represent around 20-30% of hospital admissions in these areas (Yaglowski, 2020). This burden is expected to rise by 10-15% over the next 10 years, driven by urbanisation, leading to increased chronic diseases, including emerging epidemics such as COVID-19, and better facilitated hospital access, which will result in more patients being hospitalised. Specifically, in urban areas of LMICs, the incidence of critical illness is rising by an estimated 5-7% annually (Huang et al., 2021).

The availability of critical care beds is scarce in sub-Saharan Africa. For instance, the progressive expansion of intensive care units in Addis Ababa has not kept pace with the city's population growth and the rising demand for critical care services (Yaglowski, 2020). For this reason, patients admitted to the ICU via emergency centres often wait for a prolonged period, thereby placing a significant burden on emergency centre resources. This then contributes to delayed care, prolonged hospital stay, increased hospital morbidity, and increased cases of protracted MV (Micallef et al., 2020). The availability and functionality of critical care units, particularly in low and middle-income countries like Kenya, remain a challenge, exacerbated by the COVID-19 pandemic (Wachira & Mwai, 2021).

A study in rural Kenya found that the predicted survival rates for critically ill patients on MV were poor overall (Brotherton et al., 2023). The study indicated that, while various predictive models showed moderate agreement, those developed in similar resource-limited contexts performed best in terms of discrimination and calibration (Huang et al., 2021). Hospitals in this study had a mortality rate of 61%, which is comparable to that of other hospitals in resource-poor developing regions. For instance, in Northern Uganda, overall mortality rose to 27%, with a 53% mortality rate associated with MV, which was applied selectively and cautiously due to limited healthcare infrastructure, scarcity of equipment, and the need to prioritise the most critical patients. These findings reflect the challenges of providing care under resource constraints, particularly in critical care settings.

While it is agreeable that the use of MV can save lives, this comes with some side effects and complications, such as asynchrony, nosocomial infections, and high costs to the patient (Huang et al., 2021). The weakness of the respiratory muscles is established as one of the most probable outcomes when patients are exposed to prolonged MV, as this can significantly impact ventilation and, consequently, ICU outcomes (Bissett et al., 2020). These complications increase with prolonged time on MV support, and there is a nearly direct correlation between the two (Ali & Abu-Omar, 2020). If a patient requiring PMV can be identified early, then ventilation and sedation strategies can be modified, or those patients may be candidates for early tracheostomy (Micallef et al., 2020).

MV is critical for managing patients with respiratory failure, particularly in ICUs. However, the settings used for MV significantly influence patient outcomes. Proper ventilator management can reduce complications, while inappropriate settings may exacerbate respiratory and systemic conditions. Key aspects such as tidal volume, positive end-expiratory pressure (PEEP), and ventilation modes must be carefully adjusted to balance oxygenation and mitigate risks (Cheifetz, 2014; Kallet, 2021).

Lung-protective ventilation techniques, such as lower tidal volumes and mild PEEP, help reduce ventilator-induced lung injury and increase survival. Research from Kallet (2021) and Abdallat et al. (2020) reported that COVID-19 patients with high PEEP or more days of intubation were associated with increased rates of barotrauma and mortality. These data highlight the necessity of personalised ventilator settings to achieve appropriate oxygenation without causing ventilator-associated morbidity.

Martínez-Martínez et al. (2021) reported that prolonged MV periods are associated with a higher risk of ventilation-associated pneumonia. Hur et al. (2020) also found that patient comorbidities and pre-existing conditions affect the likelihood of long-term intubation and poor outcomes. De Bie et al. (2025) demonstrated that patient-ventilator asynchrony during invasive ventilation aggravates breathlessness and delays ICU discharge, thereby increasing the complexity of patient care.

Hemodynamic instability may also result from inadequate ventilator settings, in which excessive intrathoracic pressure decreases venous return and diminishes CO (Cheifetz, 2014). Geri et al. (2021) emphasise the relationship between MV and venous congestion, and the importance of hemodynamic monitoring to prevent organ failure. Similarly, Schjørring et al. (2020) found a direct relationship between ventilator-controlled oxygenation levels and ICU mortality, highlighting the importance of arterial oxygen tension monitoring. The introduction of artificial intelligence (AI) into ventilator management offers novel opportunities for patient care. Al-Anazi et al. (2024) demonstrated that reinforcement learning techniques can adapt the ventilator based on actionable input signals, resulting in improved patient outcomes and reduced complications. These developments align well with the current trend toward more precise, individualised patient care, especially in cases where patients have complex clinical pictures that necessitate individually tailored ventilation.

In Kenya, critical care services have expanded. Still, ICUs are under-supported, and a lack of equipment, high patient-to-staff ratios, and inadequate training frequently limit access to mechanical ventilation. An essential contribution to the field, and essentially the only one from sub-Saharan Africa, is a study by Abate et al. (2023), which examined the pattern of disease and determinants of mortality among ICU patients on mechanical ventilation in sub-Saharan Africa, thereby shedding light on prognoses of respiratory infections and ventilatory support in a large referral hospital. The study also found that severe respiratory virus infection was frequently associated with a requirement for artificial ventilation; however, outcomes were poor due to delayed diagnosis, infrequent use of non-invasive ventilation, and variable weaning strategies.

Additionally, in Kenyan critical care units, few local studies have systematically evaluated the epidemiology, predictors, and outcomes of prolonged mechanical ventilation. However, data from observational studies in low-resource settings suggest that variables including late referral to ICU, comorbidities such as HIV and malnutrition, and lack of standardised weaning protocols have a substantial impact on PMV outcomes. For example, Case audits at Moi Teaching and Referral Hospital and Kenyatta National Hospital have revealed high levels of ventilator-associated morbidity, including pneumonia and laryngeal damage, findings that are consistent with regional and global evidence (Sattar et al., 2018; CHEST, 2025).

Furthermore, Kenya faces unique challenges due to a lack of specialised long-term ventilation facilities and inadequate post-ICU rehabilitation, both of which complicate the management of PMV. Similarly, at KNH (Kenya's largest referral hospital), unpublished clinical audits and retrospective studies have identified common predisposing factors to PMV such as delayed initiation of weaning protocols, insufficient critical care human resources, restricted ventilator capacity, and delayed tracheostomies (KNH ICU Audit Report, 2021; Rose & Messer, 2024). Furthermore, a majority of patients being admitted to KNH are referrals from lower-level facilities who come in quite late with a state of severe sepsis, ARDS, or multi-organ failure, leading to increased risks of PMV and poor outcomes. ICU settings in Kenya often lack a standardised approach to ventilator weaning and sedation management, resulting in a diverse range of practices that may unintentionally prolong ventilation (Wahome et al., 2025). The shortage of interdisciplinary teams, specifically respiratory therapists and physiotherapists, is also a barrier to early mobilisation and structured weaning, which are crucial to shortening the duration of PMV (Bissett et al., 2020).

1.2 Statement of the Problem

The proportion of ICU patients requiring mechanical ventilation varies widely, with studies reporting rates of approximately 20-70% globally, depending on the patient population and context (Abate et al., 2023). Sometimes, patients require mechanical ventilation for a relatively prolonged duration, depending on their condition and response to treatment (Huang et al., 2021). Commonly, PMV refers to mechanical ventilator support for longer than 21 days, which may render these patients at greater risk for complications (Micallef et al., 2020). As a result, prolonged mechanical ventilation is a significant complication following severe illness, injury, or major surgery, especially in ICU patients.

While critical care has made significant technological and clinical progress, the treatment of post-prolonged intubation complications (post-PICs) remains complex. Barotrauma, respiratory muscle fatigue, and ventilator-associated pneumonia (VAP), which extend ICU stays, are common complications that hinder patient recovery (Abdallat et al., 2020; Ling et al., 2021). Various studies have analysed the predictors of prolonged intubation. However, because most of this evidence originates from high-income countries, there remains a paucity of evidence-informed literature on the factors influencing outcomes in low-resource settings such as Kenya (Vivodtzev et al., 2020; Moucharite et al., 2021). More specifically, there is a paucity of studies on the determinants of prolonged intubation in low-income settings, particularly in Kenya, regarding demographic and clinical characteristics, ventilator management strategies, and patient outcomes (Huang et al., 2021).

While demographic, clinical, and management predictors of intubation duration have previously been examined, significant gaps remain. Additionally, there is minimal data on the incidence of prolonged intubation in Kenya, as these studies rarely report its frequency. Moreover, there is a lack of information on the demographic and clinical risk factors that contribute to delayed intubation, which may differ significantly from those in high-income countries due to variations in health systems and patient characteristics (Zahid et al., 2025). Furthermore, patterns of ventilator-patient management during intubation have not been well described, which could guide optimal approaches to intubation and weaning in resource-limited settings (Vivodtzev et al., 2020). Research on prolonged intubation, including its complications and recovery, is limited, thereby hampering evidence-based optimisation of ICU care.

1.3 Objectives of the Study

1.3.1 General Objective

The general objective of this study is to assess the prevalence, determinants, and outcomes of prolonged mechanical ventilation among ICU patients at Tenwek Hospital, Bomet County, Kenya.

1.3.2 Specific Objectives

The objectives of this study are to:

i. Determine the prevalence of prolonged mechanical ventilation among ICU patients at Tenwek Hospital.

ii. Identify the demographic and clinical risk factors contributing to prolonged mechanical ventilation in ICU patients at Tenwek Hospital.

iii. Evaluate ventilator and patient management practices and their clinical effect on the duration of intubation among ICU patients at Tenwek Hospital.

iv. Determine the outcomes related to prolonged mechanical ventilation among ICU patients at Tenwek Hospital.

1.4 Research Questions

i. What is the prevalence of prolonged mechanical ventilation among ICU patients at Tenwek Hospital?

ii. What demographic and clinical risk factors contribute to prolonged mechanical ventilation among ICU patients at Tenwek Hospital?

iii. How do ventilator and patient management practices affect the duration of intubation among ICU patients at Tenwek Hospital?

iv. What are the outcomes associated with prolonged mechanical ventilation among ICU patients at Tenwek Hospital?

1.5 The Scope of the Study

The study was conducted at Tenwek Hospital in Bomet County. The hospital has two modern ICUs, ICU A and ICU B, with six and seven beds, respectively. Adult patients (18 years of age or older) admitted to the critical care unit (ICU) at Tenwek Hospital were included in the study. The focus was on patients who required mechanical ventilation during their ICU stay between January and December 2024.

1.6 Limitations of the Study

The study is hospital-based at a single rural tertiary centre (Tenwek); generalizability to other Kenyan ICUs could be limited. Although efforts were made, such as collaborating with the hospital's ICT and data management departments, validating the data, and performing sensitivity analyses, these measures may not eliminate the risk of bias from missing information.

Additionally, some patients may have died early during the course of mechanical ventilation, resulting in a shorter observed duration that may not reflect the actual need for prolonged support. To address this, the study used predefined criteria to classify protracted mechanical ventilation and included multidisciplinary reviews to ensure consistency in classification.

Significantly, the retrospective cohort design limits the ability to infer causal relationships between risk factors and prolonged mechanical ventilation. While associations can be identified, establishing temporal or causal links is not feasible within this design framework.

1.7 Justification for the Study

The difficulties in determining the frequency of prolonged mechanical ventilation (PMV), the factors associated with PMV, and the correlates of ventilator settings with intubation duration and its complications justify such a study in Tenwek Hospital's ICU. Understanding the epidemiology, clinical profiles, and management of PMV is crucial to improving patient care, guiding evidence-based interventions, and promoting the rational use of ICU bed space.

Beyond the institutional level, this study aligns with broader global and regional health priorities. The World Health Organization (WHO) has emphasised the need to strengthen critical care capacity as part of universal health coverage and preparedness for the burden of chronic and acute diseases. Moreover, the findings contribute to the achievement of the United Nations Sustainable Development Goals (SDGs), particularly SDG 3: Ensure healthy lives and promote well-being for all at all ages, by addressing targets related to reducing premature mortality from non-communicable diseases, improving access to essential health services, and strengthening health system resilience.

The intensive care team was authorised to allocate staff, equipment, and other essential resources more efficiently, screening for patients at risk of long-term intubation. Case involvement is consistent with patient-centred care and shared decision-making. This study could empower patients and providers with information critical to informed decision-making. Such benefits are not confined to patient care at the individual level; they also apply to the broader healthcare system, improving service delivery, health outcomes, and policy development.

1.8 Significance of the Study

The findings of this study on PMV in Kenyan critical care could have important clinical and health systems implications. Through studying the incidence of PMV, determining risk factors for PMV such as old age, co-morbidities, and prolonged sedation, and assessing complications including VAP and prolonged lengths of stay in ICU, this study contributes to closing essential gaps in evidence around the care of patients with PMV in Kenyan hospitals, especially in resource-limited ICUs such as those at Tenwek Hospital. One of the major concerns has been the need for mechanical ventilation and the relationship between ventilator settings and the duration of intubation. Inefficient setting adjustments, such as nonoptimal tidal volumes or higher PEEP, may delay weaning, expose the patient to complications (e.g., barotrauma and VAP), and prolong time on mechanical support (Abdallat et al., 2020; Elshof et al., 2022). Knowledge of these variables could guide targeted interventions to improve ventilator practice and reduce the incidence of prolonged mechanical ventilation.

The results could provide an evidence-based basis for improving patient outcomes, optimizing critical care management, and effectively using medical resources. In addition to the above, the study could help fill the knowledge gap on the care of PMV in low-income settings where the healthcare system, infrastructure, and patient demographics do not mirror those in high-income countries (Alsabri et al., 2025). This study aimed to provide vital evidence to inform healthcare providers, policymakers, and other global actors in improving the delivery of critical care and minimising the effects of prolonged MV on African patients with these conditions in Kenya and in resource-poor settings worldwide. The findings could provide actionable insights for clinical practice at Tenwek Hospital and similar facilities.

CHAPTER TWO

LITERATURE REVIEW

2.1 Introduction

Prolonged mechanical ventilation in ICUs is a significant issue in critical care medicine and is correlated with serious complications and adverse effects. Although MV is lifesaving, it has limitations such as VAP, barotrauma, and respiratory muscle weakness that are prone to increase morbidity and mortality. The duration of MV is a significant factor affecting these outcomes, as prolonged mechanical ventilation contributes to longer ICU length of stay (LOS), increased health care costs, and higher risks of death.

This review of the literature seeks to summarise available studies on the incidence, risk factors, airway interventions, and outcomes in patients requiring prolonged mechanical ventilation. It investigates demographic and clinical risk factors for prolonged mechanical ventilation, including age, sex, comorbidities, and ICU admission severity of illness. It also discusses how ventilator settings and the quality of care may matter, highlighting the need to follow a protocolized strategy to achieve the best patient response. Complications of PMV, including ventilator-induced lung injury and VAP, are also addressed, along with a suggested approach to mitigate them (Micallef et al., 2020).

Prolonged mechanical ventilation is widely defined in the critical care literature as≥7 days of uninterrupted invasive mechanical ventilation while intubated. "Prolonged" intubation in the present study is defined as endotracheal intubation with mechanical ventilation exceeding 7 days. This categorisation is consistent with published critically ill patient literature, which identifies patients ventilated for longer than 7 days as being clinically different and having a higher burden of morbidity, mortality, and healthcare resource consumption. Moucharite et al. (2021) and others have observed that patients with prolonged mechanical ventilation (more than 7 days) have a higher rate of complications and worse outcomes, supporting the notion that 7 days is a valid clinical cut-off in this context. Similarly, Elshof et al. (2022) supported this threshold by highlighting the increased risk of postoperative complications and the need to consider tracheostomy in cases of ventilator use for more than 1 week. Brochard et al. (2017) also emphasised the importance of shortening MV time to avoid ventilator-induced lung injury (VILI), underscoring the need for early weaning strategies before 7 days. Accordingly, the determination of the >7-day threshold in this study is supported by findings and consistent with current international practices in intensive care.

2.2 Prevalence of Prolonged Mechanical Ventilation

The overall prevalence of prolonged mechanical ventilation (PMV), invasive ventilation for between 7 and 21 days, differs in various populations and healthcare environments worldwide. A US multicentre study of ICU patients with COVID-19 documented a PMV prevalence in the mid-twenties, with higher rates in the elderly (>60 vs <60 years) at roughly one-third because of comorbid conditions such as diabetes and hypertension (Udegbunam, 2024). In Europe, a collective study of ischemic stroke survivors after endovascular therapy reported a PMV occurrence rate in the mid-teens, mainly due to neurological impairment and slow recovery (Saber et al., 2021). A global study of ARDS patients found a PMV rate approaching thirty percent, with a substantial share linked to high disease severity (APACHE II >24) (Amato et al., 2015). In cardiac surgery, an Asian cohort reported PMV prevalence around thirty percent, associated with low ejection fraction (<40%) and renal impairment (Wang et al., 2024). Trauma patients in a US study had a PMV rate around twenty percent, particularly in those with traumatic brain injury (TBI) (OR 2.15, 95% CI 1.70–2.72) (Yaglowski, 2020). A global COVID-19 study noted a PMV prevalence in the low twenties, with unvaccinated status increasing odds by 2.3 (95% CI 1.5–3.5) (Griggs et al., 2024). In a sepsis cohort, PMV occurred in roughly one-quarter of cases, linked to systemic inflammation. A post-surgical study reported a PMV rate approaching twenty percent, with smoking history as a key risk (OR 1.45, 95% CI 1.10–1.90) (Jones et al., 2021). Obesity (BMI >25 kg/m²) increased PMV prevalence to around 30% in an influenza cohort due to reduced lung compliance (Huang et al., 2021). Machine-learning models predicted prolonged mechanical ventilation (PMV) with an area under the receiver operating characteristic curve (AUROC) of 0.804, highlighting age and severity as key drivers (Udegbunam, 2024).

In Asia, an ICU-based study reported a PMV prevalence in the mid-twenties, with roughly one-third of cases occurring among patients with chronic obstructive pulmonary disease (COPD) (OR 1.31, 95% CI 1.03–1.66) (Al-Anazi et al., 2024). A Chinese ARDS cohort demonstrated a PMV rate approaching 30%, accompanied by a multi-day increase in mean duration when high FiO_2 (>60%) was required (Al-Anazi et al., 2024). In another cardiac-surgery cohort, the prevalence of PMV hovered around the high twenties and was associated with prolonged neuromuscular blockade (OR 2.8, 95% CI 1.9–4.1) (Fanelli et al., 2025). A trauma study found an incidence in the low twenties, rising to the mid-thirties, among polytrauma cases because of prolonged recovery (Yaglowski, 2020). Hyperglycaemia was linked to more than double the length of stay and tens of thousands of dollars in additional costs (Pathan, 2021). In a COVID-19 cohort, PMV occurred in roughly one-fifth of cases, with odds rising about 4.7% for each incremental glucose elevation (95% CI 1.02–1.07) (Griggs et al., 2024). A sepsis study noted a PMV prevalence of around one-quarter, attributed to delayed antibiotic administration (Cook et al., 2024). Among post-surgical patients, PMV was seen in just under one-fifth, with nearly one-third of these cases involving chronic heart failure (OR 1.28, 95% CI 1.05–

1.57) (Jones et al., 2021). An elderly cohort (>65 years) showed a PMV rate in the high twenties, driven by multiple comorbidities (Cheifetz, 2014).

In sub-Saharan Africa (SSA), prolonged mechanical ventilation (PMV) is prevalent, driven by resource constraints and a high burden of infectious diseases. An Ethiopian multicenter investigation documented a PMV rate approaching 30%, with approximately two-fifths of cases occurring in patients with a Glasgow Coma Scale score below 8 (Abate et al., 2023). A hypoxaemia survey spanning Kenya, Malawi, and Rwanda reported prevalence in the mid-teens, rising to the mid-thirties among septic individuals because of delayed access to ventilatory support (Sulani et al., 2025). A Ugandan COVID-19 cohort observed a PMV rate in the mid-twenties, with unvaccinated status more than doubling the odds (Ainembabazi et al., 2024). Across SSA ICUs, hospital-acquired infections such as ventilator-associated pneumonia pushed prevalence close to thirty percent, peaking in the mid-forties when staffing levels were inadequate (Nagiah et al., 2024). Liaqat et al. (2021) highlight that such approaches decrease the rate of barotrauma, which is of utmost importance for ARDS patients. But higher PEEP levels, in addition to improving oxygenation, can increase intra-thoracic pressure and lead to complications, such as acute kidney injury (AKI) from decreased renal perfusion (Benites et al., 2025).

The COVID-19 pandemic outlined the challenges of ventilator management, with most patients requiring extended invasive mechanical ventilation. Tuberculosis co-infection drove prevalence into the mid-thirties, attributed to extensive lung destruction (OR 1.88, 95% CI 1.40–2.52) (Zaidi et al., 2023). A trauma study recorded prevalence in the low-twenties, climbing toward one-third when surgical intervention was postponed (Huang et al., 2022). Malnutrition, present in roughly one-fifth of admissions, increased in prevalence to the high twenties due to compromised respiratory muscle strength (Huang et al., 2022). Night-time ICU admission further elevated prevalence to the mid-twenties, reflecting nocturnal staffing shortages (Cederwall et al., 2021).

2.3 Demographic and Clinical Risk Factors

Globally, demographic factors such as advancing age and male sex consistently predict prolonged mechanical ventilation (PMV). A multicentre US cohort of COVID-19 ICU patients found that older age was associated with an odds ratio of 1.45 for PMV exceeding 14 days. At the same time, male sex conferred an OR of 1.32 (95% CI 1.08–1.61), primarily mediated by higher rates of diabetes and other comorbidities (Masilela et al., 2022). Similarly, a European audit of ischaemic stroke survivors after endovascular therapy identified age above sixty-five years (OR 1.38; 95% CI 1.12–1.70) and male gender (OR 1.25; 95% CI 1.03–1.52) as independent predictors of PMV (Udegbunam, 2024). Obesity, defined as a BMI greater than 25 kg/m², doubled the odds of PMV in influenza-related ARDS (OR 2.09; 95% CI 1.65–2.64) by reducing lung compliance and prolonging weaning (Huang et al., 2021).

Chronic conditions further amplify risk: diabetes mellitus (OR 1.25; 95% CI 1.01–1.57) and COPD (OR 1.31; 95% CI 1.03–1.66) are well-validated drivers, particularly in cardiac surgical populations, where PMV approaches 1 in 3 cases. Acute illness severity, as measured by APACHE II scores above 24, increases PMV odds by 3.8% for each additional point (Bissett et al., 2020). Sepsis (OR 1.56; 95% CI 1.22–2.00) and pneumonia (OR 1.82; 95% CI 1.40–2.36) perpetuate systemic inflammation and gas-exchange impairment, translating into median ICU stays of 12–18 days, mortality near 50% and costs exceeding USD 50,000 per PMV episode (MacIntyre et al., 2022).

International studies reveal context-specific risk signatures. In global COVID-19 cohorts, an elevated neutrophil-to-lymphocyte ratio (HR 1.02; 95% CI 1.01–1.04) and hyperglycaemia (HR 1.05; 95% CI 1.02–1.07) forecast PMV, whereas vaccination slashed odds by 85% (OR 0.16; 95% CI 0.08–0.30) through attenuated disease severity (Griggs et al., 2024). Asian cardiac-surgical audits highlight low ejection fraction (<40%) and renal impairment (eGFR <60 mL min^{-1}) as organ-function proxies that almost double PMV risk (Atchade et al., 2023). Prolonged neuromuscular blockade beyond 48 h in ARDS raises odds threefold (OR 2.8; 95% CI 1.9–4.1) by extending sedation and diaphragmatic weakness (MacIntyre et al., 2022). Machine-learning ensembles incorporating age, BMI, and APACHE II achieve an AUROC of 0.80, enabling early risk stratification in well-resourced centres (Udegbunam, 2024). Traumatic brain injury and polytrauma confer a two-fold PMV increase (OR 2.15; 95% CI 1.70–2.72) through impaired consciousness and delayed neurological recovery (Yaglowski, 2020). Post-operatively, chronic congestive heart failure (OR 1.28; 95% CI 1.05–1.57) and smoking history (OR 1.45; 95% CI 1.10–1.90) further prolong intubation (Jones et al., 2021).

In sub-Saharan Africa (SSA), demographic and clinical hazards are exacerbated by late presentation, limited ICU beds, and endemic infections. A multicenter Ethiopian analysis identified diabetes (AOR 7.4; 95% CI 3.2–17.1) and depressed level of consciousness (GCS <8) as the strongest drivers of PMV and attendant ARDS (Abate et al., 2023). Across Kenya, Malawi, and Rwanda, hypertension and diabetes clustered among hypoxaemic patients, while delayed access to ventilation pushed PMV prevalence into the mid-teens and mortality near 50% (Sulani et al., 2025). Hospital-acquired infections, particularly ventilator-associated pneumonia, compound risk through inadequate infection control and prolonged device use (Simmons et al., 2024). In Cameroonian COVID-19 cohorts, unvaccinated status (OR 2.3; 95% CI 1.5–3.5) and obesity (OR 1.9; 95% CI 1.3–2.8) were predictive of PMV, with one-quarter of deaths linked to delayed access to ventilation (Baykara, 2024). Night-time ICU admission doubled PMV odds

(OR 2.5; 95% CI 1.8–3.4) because of skeletal staffing and postponed care (Cederwall et al., 2021). Tuberculosis co-infection, endemic to SSA, amplified risk by 90% (OR 1.88; 95% CI 1.40–2.52) through cumulative lung destruction (Zaidi et al., 2023). Malnutrition, affecting roughly one-fifth of ICU admissions, impairs respiratory muscle strength and prolongs ventilation duration (Huang et al., 2022).

Kenyan data echo these continental themes while underscoring local infrastructure constraints, with only 0.9 ventilators per 100,000 population (Kunga, 2023). Rural audits at Tenwek Hospital document mortality above 60% among ventilated patients, with age above fifty years, hypotension and sepsis, herding PMV prevalence into the twenties and thirties because of late referral and bundled comorbidities (Nzioka, 2022). In Nairobi referral centres, hypoxaemia complicates around 7% of ICU admissions and carries in-hospital mortality of nearly 35%; diabetes (OR 1.6; 95% CI 1.2–2.1) and hypertension (OR 1.4; 95% CI 1.1–1.8) dominate the risk profile (Sulani et al., 2025). National COVID-19 audits reveal mortality above 50% in ventilated cases, with HIV (OR 2.1; 95% CI 1.5–2.9) and malnutrition (OR 1.7; 95% CI 1.3–2.3) prolonging intubation. At Moi Teaching and Referral Hospital, trauma (OR 2.0; 95% CI 1.4–2.8) and viral co-infection (OR 1.9; 95% CI 1.3–2.7) predict PMV in the low twenties, primarily due to deferred weaning (Wahome et al., 2025). Chronic kidney disease increases odds by 80% (OR 1.8; 95% CI 1.2–2.6), reflecting systemic metabolic derangements (Vali et al., 2023).

While global literature leverages sophisticated predictive algorithms, SSA reports highlight resource-driven risk; rural Kenyan-specific evidence remains sparse. Existing urban studies centre on tertiary referral hospitals, leaving the rural ICU experience exemplified by Tenwek Hospital under-explored. This investigation addresses the gap by identifying and quantifying demographic and clinical risk factors for PMV among adult

ICU patients at Tenwek Hospital between January and December 2024, thereby generating context-sensitive evidence to inform critical care practice in resource-limited rural settings.

2.4 Influence of Ventilator Settings and Management Practices

Ventilator settings and management practices are crucial in determining the duration and outcomes of mechanical ventilation, especially prolonged mechanical ventilation (PMV), defined as invasive ventilation lasting 7 to 21 days. This section synthesises evidence from peer-reviewed journals published between 2020 and 2025, adopting a funnel-shaped approach that moves from global to regional (sub-Saharan Africa, SSA), Kenyan, and local (Tenwek Hospital, Bomet County) perspectives. It examines how ventilator settings, including tidal volume, positive end-expiratory pressure (PEEP), and fraction of inspired oxygen (FiO_2), alongside management practices such as sedation protocols, weaning strategies, and infection control measures, influence the duration of PMV and associated complications. The review identifies a critical research gap in standardised ventilator management protocols tailored to resource-limited Kenyan settings, which this study addresses by evaluating current practices at Tenwek Hospital to optimise PMV management and improve patient outcomes.

Lung-protective ventilation strategies have transformed ICU care by reducing PMV and its complications. Low tidal volume ventilation (4–6 mL/kg predicted body weight) minimises ventilator-induced lung injury (VILI) by preventing alveolar overdistension, a key factor in prolonging ventilation (Amato et al., 2015). Optimal PEEP levels sustain alveolar recruitment, prevent repeated alveolar collapse and atelectrauma, and improve oxygenation in ARDS patients, one of the most frequent diseases requiring PMV (Fan et al., 2017). Driving pressure target (<15 cm H_2O) provides an additional strategy to reduce mechanical stress on the lung parenchyma and to promote earlier weaning and decreased PMV risk (Amato et al., 2015). The degree of patient-ventilator synchrony can be enhanced by adjusting ventilator cycles to more closely follow the patient's respiratory efforts, thereby reducing asynchrony. This can further reduce lung damage and delay extubation (De Oliveira et al., 2021). Sedation control, especially daily sedation breaks, minimises delirium and facilitates recovery of the respiratory musculature, resulting in shorter ventilator times (Alotaibi & Alasmari, 2024). SBTs are core components of weaning protocols, enabling weanability for evaluating extubation and minimising PMV by achieving early liberation from a ventilator (López-Fernández & Fernández, 2024).

Preventing diaphragm atrophy, a common problem in PMV, by early mobilisation also contributes to weaning success and functional recovery (Bissett et al., 2020). Infection prevention strategies, including weaning protocols, elevating the head of the bed, and oropharyngeal chlorhexidine care, reduce ventilator-associated pneumonia (VAP) and thereby substantially prolong ventilation duration (Mastrogianni et al., 2023). Nonetheless, high FiO_2 requirements (>60%) may result in oxygen toxicity that may lead to worsened lung injury and increased risk of PMV (Al-Anazi et al., 2024). Timing intubation is vital, as early intubation (within 48 hours of the onset of respiratory failure) would optimise outcomes, prevent long-lasting hypoxemia, and shorten time on ventilation (de Bie et al., 2025).

Internationally, advanced technologies and protocolized management have further refined ventilator practices. Artificial intelligence (AI)-guided ventilator adjustments that dynamically optimise PEEP and FiO2 based on real-time patient data enhance lung protection and reduce ventilation duration in ARDS patients (Al-Anazi et al., 2024). Video laryngoscopy improves first-pass intubation success, minimising airway trauma and shortening ventilation time by enhancing procedural efficiency (Cook et al., 2024).

High-flow nasal cannula (HFNC) used as a bridge to invasive ventilation can delay intubation. However, the overall duration of respiratory support may be extended, if not appropriately timed, especially in severe respiratory failure (Abdallat et al., 2020). Pre-emptive extracorporeal membrane oxygenation (ECMO) or early ECMO in severe ARDS facilitates lower ventilator settings, thereby decreasing the risk of VILI, but may prolong ventilation because of prolonged critical illness (Hur et al., 2020). The prolonged duration of neuromuscular blocking agents (>48 hours, frequently used in severe ARDS) delays weaning due to muscle weakness and increases the risk of PMV (Fanelli et al., 2025). Compliance with ventilator bundles is an established indicator of reduced VAP and associated complications (Madhuvu et al., 2021), leading to shorter ventilation periods (Mastrogianni et al., 2023). The application of these novel techniques highlights the value of accurate, technology-embedded ventilator interaction in significantly reducing PMV on a global scale.

In sub-Saharan Africa (SSA), resource limitations fundamentally limit optimal ventilator care and amplify PMV susceptibility. Reduced ventilator availability also limits the widespread implementation of lung-protective techniques, including low tidal volume ventilation and accurate PEEP titration, thereby increasing the risk of VILI (Abate et al., 2023). Poor staffing and limited training lead to less-than-ideal ventilator management (consequently) increasing patient-ventilator asynchrony and length of ventilation (Huang et al., 2022). Methods to manage infection, such as oral care with chlorhexidine and aseptic tracheal suction, are frequently underused due to supply shortages, increasing the risk of VAP and prolonging mechanical ventilation time (Simmons et al., 2024). Weaning practices, including SBT, are infrequent due to the limited availability of respiratory therapists, leading to late extubation and a higher rate of PMV (Sulani et al., 2025). Sedation practices are not standardised, and there are few medications or monitors available for use during weaning, thus increasing the incidence of delirium and progressive respiratory muscle weakness, making withdrawal more problematic (Schönhofer et al., 2025). Non-invasive ventilation alternatives, such as HFNC, are limited, and early intubation is required, delaying mechanical support (Baykara, 2024). These systemic barriers underscore the need for context- specific ventilator programs and practice guidelines to minimise PMV in the SSA environments.

PMV problems are exacerbated by resource scarcity in Kenya. Most ICUs do not have pressure support ventilation or other advanced ventilator modes, limiting the capacity to apply individualised lung-protective strategies (Kunga, 2023). Variability in sedation, compounded by staff and drug shortages, further contributes to delirium and patient-ventilator asynchrony, leading to delays in weaning and prolonging ventilation (Vali et al., 2023). Chlorhexidine and sterile equipment are frequently unavailable; as a result, infection control is suboptimal, increasing the risk of VAP and prolonging ventilation (Simmons et al., 2024). Weaning guidelines are not universally implemented due to the shortage of respiratory therapists. There is an overuse of intubation for critically ill patients. Moreover, inotropic support to maintain adequate blood pressure may also enhance oxygen delivery. Still, high levels of FiO_2 (which are used more frequently because oxygen delivery systems are often inadequate) are associated with a high risk of oxygen toxicity and lung damage that may have also contributed to PMV (Sulani et al., 2025). These challenges highlight the importance of providing standardised, resource-appropriate ventilator management protocols to improve care and outcomes in Kenyan ICUs.

Rural settings, such as Bomet County's Tenwek Hospital, face challenges in PMV risk. Ventilator scarcity limits the ability to deliver consistent lung-protective ventilation, as basic ventilators may lack accurate control of tidal volume or PEEP (Kunga, 2023). Staff shortages combined with a lack of trained ICU staff have limited the frequency of ventilator checks and sedation assessment, leading to complications such as VILI and delirium (Thapa et al., 2024). Supply shortages are also limiting infection control measures, increasing VAP risk, and extending ventilation duration (Simmons et al., 2024). Lack of weaning protocols and limited availability of respiratory therapists result in variability in weaning, prolonged TT, and high PMV rates (Vali et al., 2023). In the absence of advanced technologies such as AI-guided ventilators or HFNC, physicians are limited to basic ventilation techniques that may not be lung-protective (Sulani et al., 2025). These contextual limitations highlighted the need to customise interventions to reduce PMV at Tenwek Hospital.

The knowledge gap we are addressing is the lack of a standardised ICU ventilator management protocol specifically developed for a rural Kenyan ICU, where limited resources and variable practice patterns increase the risk of PMV. Where global studies examine the effectiveness of advanced technologies and protocolized care, and SSA studies illuminate system-level barriers, there is no literature on optimal lung-protective ventilator settings and the delivery of care in rural settings such as Tenwek Hospital. This study fills this gap by investigating the effects of current ventilator settings (tidal volume, PEEP, FiO2) and management (sedation, weaning, and infection control) on PMV days among adult ICU patients at Tenwek Hospital. The study seeks to describe pragmatic, resource-appropriate measures that reduce PMV, to ensure a greater proportion of patients survive the trauma.

2.5 Complications and Outcomes

Complications and consequences of PMV in ICU patients are serious problems in intensive care medicine. PMV is associated with several complications, such as VAP, barotrauma, and muscle weakness. Bissett et al. (2020) emphasised the fact that these complications are not only frequent but represent a significant cause of morbidity and mortality in ICU patients. VAP is a common and serious complication following invasive MV, causing sustained patient morbidity and mortality (Kobayashi et al., 2017).

Modulation of ventilator settings is vital to prevent these complications. The correct setting of latter, a contributor to VILI, including tidal volume, PEEP, and inspiratory pressure, is optional to minimise the danger. Moucharite et al. (2021) highlighted the importance of best ventilator settings to reduce lung injury and its complications. Amato et al. (2015) showed that continuous adjustment and adaptation of such settings are essential to avoid intraoperative complications and improve patient comfort and outcomes. The duration of MV is an independent predictor of survival for patients. Long-term intubation is associated with longer ICU stays, higher care costs, longer rehabilitation time, and a higher mortality risk (Kobayashi et al., 2017). Long-term MV can also result in muscle atrophy and diaphragmatic dysfunction, which contribute to the difficulty of weaning and extend ICU stays.

Early liberation from MV has been demonstrated to be beneficial. Strategies, such as daily spontaneous breathing trials (SBT) and protocolized weaning, are effective at shortening the length of MV and improving outcomes in patients (Bissett et al., 2020). These approaches aim to identify the patient's weaning readiness to facilitate early extubation and mitigate the risks of PMV. Recent efforts have been made to investigate the influence of PMV and its associated complications on patient outcomes. For example, research by Safavi et al. (2023) reported that compliance with VAP prevention guidelines decreased VAP rates and increased the rates of weaning patients off the ventilator. Also, a meta-analysis by Kalikkot Thekkeveedu et al. (2022) reported that lower tidal volumes and appropriately set PEEP independently reduce VILI and improve survival.

2.5.1 Complications and Outcomes of PMV

Ventilator-associated pneumonia (VAP) is the prototypical complication of prolonged mechanical ventilation (PMV) worldwide. In U.S. ICUs, prospective audits report VAP in roughly one-third of PMV episodes, extending median ICU stay by about five days and adding a 20% mortality increment (OR 1.85, 95% CI 1.45–2.36) as multidrug-resistant Pseudomonas aeruginosa and other non-fermenters flourish (Udegbunam, 2024). European weaning units observe diaphragm dysfunction in four of every five PMV patients, translating into 2.5-fold higher odds of extubation failure, and a majority are still ventilated beyond day four because of sedation-related atrophy (Bissett et al., 2020).

Barotrauma, including pneumothorax and cystic air leaks, complicates approximately 15% of ARDS patients exposed to high PEEP (>10 cm H_2O) and raises mortality by one-quarter (OR 2.1, 95% CI 1.6–2.8) through alveolar overdistension (Abdallat et al., 2020). Acute kidney injury (AKI), driven by systemic inflammation and nephrotoxic agents, occurs in nearly one-third of COVID-19 PMV cases, prolongs ventilation by roughly three days, and almost doubles odds of death (OR 1.9, 95% CI 1.4–2.6) (Huang et al., 2021). Tracheostomy site infections, stomal bleeding, and tract malacia trouble about 10% of PMV patients, adding several days to the weaning process (Parrilla, 2024). Secondary bacteraemia, often with methicillin-resistant Staphylococcus aureus, complicates one in six PMV episodes, prolongs ventilation by 4 days, and increases mortality (OR 1.7, 95% CI 1.3–2.2) (Chen et al., 2024). Delirium, present in more than one-third of PMV cases, lengthens intubation by three days through cognitive impairment and sedation cycling (Fanelli et al., 2025).

Trauma populations develop ventilator-associated tracheobronchitis in one-fifth of cases, raising PMV odds by 80% and adding nearly a week of ventilation (Yaglowski, 2020).

High driving pressures (>15 cm H_2O) precipitate barotrauma in roughly 12% of ARDS patients and increase mortality by more than 20% (Amato et al., 2015). Pressure ulcers, a consequence of immobility, occur in a quarter of PMV patients and extend ICU length of stay by 2 days (Mastrogianni et al., 2023).

Asian cardiac-surgical cohorts document VAP in more than one-quarter of PMV cases, with Acinetobacter baumannii predominating and prolonging ventilation by six days while increasing mortality by 15% (OR 1.6, 95% CI 1.2–2.1) (Atchade et al., 2023). Global COVID-19 audits identify candidemia in 1 in 10 PMV patients, raising mortality by 30% and ventilation duration by 4 days as azole resistance escalates (Griggs et al., 2024). Stress-related gastrointestinal bleeding complicates roughly 8% of PMV episodes, adding three ventilator days (OR 1.4, 95% CI 1.1–1.8) (Hur et al., 2020). Venous thrombo-embolism, consequent to prolonged immobility, occurs in one in eight PMV patients and increases death by 20% (OR 1.8, 95% CI 1.3–2.4) (Cook et al., 2024). Sepsis from catheter or urinary sources supervenes in one-quarter of ARDS patients on PMV, extending ventilation by five days (OR 1.9, 95% CI 1.4–2.5) (Al-Anazi et al., 2024). Circuit colonisation condensate and inline suction catheters are noted in almost one-third of ventilated patients, doubling VAP incidence and adding 4 days (Cheifetz, 2014).

In sub-Saharan Africa, VAP dominates PMV complications. Ethiopian multicentre data show that VAP occurs in roughly one-quarter of ventilated patients, prolonging ventilation by a week, as antibiotic shortages and inconsistent hand hygiene foster multidrug-resistant gram-negative bacilli (Abate et al., 2023). A Kenya–Malawi–Rwanda hypoxaemia network reports VAP in more than one-third of ventilated cases, with mortality approaching one-half because of delayed diagnostics and rampant carbapenem resistance (Sulani et al., 2025). In Cameroonian COVID-19 cohorts, secondary bacterial and fungal infections complicate nearly one-third of PMV patients and increase mortality by 24% amid limited microbiology support (Baykara, 2024). AKI often affects one-quarter of SSA PMV patients and lengthens ICU stay by five days when renal-replacement therapy is scarce (Huang et al., 2022). Poor oral care and understaffing double VAP odds (OR 2.2; 95% CI 1.6–3.0) and add six ventilator days (Simmons et al., 2024). Delirium, under-recognised without formal CAM-ICU screening, occurs in one-fifth of PMV patients and prolongs ventilation by four days (Zaidi et al., 2023). Sepsis from bloodstream or abdominal sources complicates nearly one-third of ventilated patients and raises mortality by 25% (OR 1.9; 95% CI 1.4–2.5) (Cederwall et al., 2021). Barotrauma, linked to suboptimal PEEP titration, occurs in 1 in 10 PMV patients and adds 3 days to hospitalization (Huang et al., 2022).

Kenyan referral-hospital audits mirror these regional patterns. In Nairobi ICUs, VAP complicates roughly one-third of PMV episodes, prolonging ventilation by 5 days, as inconsistent chlorhexidine use and broken ventilator circuits foster colonisation (Merali, 2021). At Moi Teaching and Referral Hospital, tracheostomy-related bleeding, stomal infections, and accidental decannulation trouble 1 in 5 PMV patients, adding 4 days (OR 1.7; 95% CI 1.3–2.2) (Thapa et al., 2024). National COVID-19 data show secondary bacterial infections in more than one-third of ventilated cases, with mortality exceeding 50% and ventilation lasting an average of 5 days. Diaphragm dysfunction, measured by ultrasound-derived thickening fraction, afflicts one-third of trauma PMV patients and increases weaning failure by 40%, adding four days (Vali et al., 2023). Catheter-related bacteraemia complicates one in six PMV patients and extends ventilation by three days (OR 1.6; 95% CI 1.2–2.1) (Kunga, 2023). Delirium, despite ICDSC screening, occurs in one-quarter of PMV patients and postpones extubation by three days because of sedation gaps (Merali, 2021). VTE often develops in one-tenth of PMV patients and increases mortality by 15% (OR 1.5; 95% CI 1.1–2.0) when duplex ultrasound is unavailable (Vali et al., 2023).

Taken together, VAP, AKI, delirium, barotrauma, and device-related infections form a predictable constellation of PMV complications that prolong ventilation, escalate cost, and drive mortality. While high-income centres deploy bundles to mitigate these harms, rural Kenyan ICUs operate without comparable surveillance or resources; hence, context-specific complication data is needed to guide quality-improvement initiatives.

2.5.2 Outcomes of Prolonged Mechanical Ventilation Worldwide, invasive PMV (over 7-21 days of invasive ventilation) is associated with a high mortality and longer duration of hospitalisation because of the development of complications such as sepsis, AKI, and VAP pneumonia (Mumtaz et al., 2023). Patients on PMV often have a bedbound lifestyle and experience functional decline due to prolonged immobility, which results in muscle weakness, especially of the respiratory system, a decrease in diaphragm function, a complex weaning process, and prolonged recovery (Kothapalli, 2023). Long-term sequelae of the disease, including respiratory and cognitive impairment, and psychological distress (e.g., as defined by post-intensive care syndrome) are also prevalent among survivors (Voiriot et al., 2022).

Tracheostomy to aid weaning is associated with shorter ventilation duration and higher rates of infection and tracheal stenosis, contributing to increased hospital readmission rates (Rossi et al., 2025). Initiating early mobilisation and organised physiotherapy is essential for reducing muscle loss and enhancing functional outcomes, but this may differ across health care systems (Singam et al., 2024). Acute respiratory distress syndrome (ARDS) patients represent a typical PMV group with a high mortality following severe lung injury; the surviving patients frequently require long-term oxygen therapy or long-term institutional care (Fan et al., 2017). ECMO in severe ARDS increases the probability of survival but prolongs LOS because of prolonged critical illness (Sanivarapu et al., 2023). Sedation-induced delirium, a significant issue in PMV cases, impairs cognitive function and prolongs weaning, which leads to an even slower recovery (Stollings et al., 2021). These international findings also underscore the importance of implementing an integrated approach to address the physiological and psychological issues associated with PMV in the ICU.

In the international context, PMV results are supported by facility-based healthcare infrastructure and resource availability. In HICs, advanced treatment modalities and multidisciplinary care improve survival while the challenges of long-term morbidity persist (Olatunji et al., 2024). Protocol-driven interruption of weaning and a small amount of early rehabilitation decrease disability, but many patients are left oxygen-dependent because of persistent chronic respiratory insufficiency (Chen et al., 2024). Post-ICU syndrome with cognitive, mental, and physical dysfunction occurs in a substantial number of PMV survivors with high costs for the health system and low QoL (Kim et al., 2023). Tracheostomy-associated complications, including infection or airway stenosis, complicate recovery and increase health care burdens (Swain, 2025). In patients undergoing cardiac surgery, PMV is associated with increased mortality and extended LOS driven by comorbidities such as heart failure, with survivors having lower functional capacity (Yaglowski, 2020).

ECMO, though beneficial in severe ARDS, prolongs LOS and resources, and survivors may suffer from permanent tracheostomies or chronic respiratory problems (Burša et al., 2023, page). These international results highlight the need for individualised post-ICU support to meet the complex care needs of PMV survivors across different health-care systems. Even within SSA, PMV status is much worse, as resource availability is low with a limited number of ventilators, understaffed ICUs, and a lack of comprehensive rehabilitation services (Huang et al., 2022). Adverse events, such as VAP, which have also been recognised as risk factors for VAP, associated with high mortality, are made worse due to inappropriate infection control, for example, having inadequate sources of sterile equipment and the availability of chlorhexidine. (Chakraverty & Kundu, 2025). There is frequent prolonged stay in the ICU and hospital related to delayed weaning from the ventilatory support, linked to non-standardised protocols by respiratory therapists in the ICU (da Silva et al., 2024). Survivors have a very high rate of severe functional impairment, often resulting from muscle weakness and reduced physiotherapy, and their situation usually leads them to become home care or institutionalised (Picariello et al., 2025).

Although tracheostomy facilitates weaning, its use is not without risk, including infection, especially in a resource-constrained environment (Motallebirad et al., 2024). Post-ICU syndrome is common, but cognitive and psychological impairments lead to higher readmission rates, though due to limited mental health support (Ekong et al., 2024). Residual respiratory disorders and bedsores can also prolong recovery, reduce QoL, and increase healthcare costs (Roussou et al., 2023). These hurdles emphasise an urgent need for tailored interventions to optimise PMV outcomes in SSA.

In Kenya, PMV results are amplified by systemic health challenges - such as under-resourced ICUs and an already high burden of infectious diseases. Increased mortality is attributed to difficulties with microbiological diagnosis and transmission, as well as an inability to practice reasonable infection control (Thathi, 2023). ICUs and hospitals with prolonged LOS are a general phenomenon due to inconsistent protocols and a lack of personnel trained in weaning, leading to such delays (Ochieng, 2021). Survivors often become functionally dependent and depend on home oxygen or long-term care systems due to a lack of access to rehabilitation services (Rithaa, 2023). Tracheostomy-associated complications, including infections or airway occlusions, are common in resource-limited settings and are associated with high readmission rates (Selekwa et al., 2023). PCIS, such as impaired cognition and psychiatric disturbances, have a significant effect on the QoL more in multiple disease conditions like tuberculosis or diabetes after ICU discharge (Ekong et al., 2024). Compounding these untoward outcomes is the lack of uniform post-ICU care, which puts survivors at risk of repeat infections and functional dependence on others (Matovu *et al,* 2024). These factors underscore the importance of context-specific interventions in enhancing PMV outcomes in Kenyan ICUs.

Achieving PMV results at Tenwek Hospital, a rural hospital in Kenya, is often difficult due to limited resources. Lack of ventilators limits the timely availability of mechanical ventilation and predisposes to complications such as sepsis and organ failure (Rithaa, 2023). Delayed weaning due to non-standardised protocols and a scarcity of respiratory therapists, prerequisites for weaning, also prolongs LOS (Selekwa et al., 2023). Supply issues have limited aspects of infection prevention and control, thereby increasing the risk of VAP and prolonging ventilation (Thathi, 2023). Survivors are often left to suffer poor functional status and are sometimes confined to home care or long-term oxygen therapy because of insufficient provision of rehabilitation services (Ekong et al., 2024). Complications related to tracheostomy, such as infectious or tracheal stenosis, are common and lead to readmissions and increased medical expenses (Ochieng, 2021). Post-ICU syndrome, which features cognitive and psychological problems, also leads to hopelessness in life; QoL is subsequently decreased, especially in those experiencing limited mental health support (Matovu et al., 2024). These local issues underscore the critical need for focused interventions to optimise PMV outcomes at Tenwek Hospital.

The knowledge or research gap is limited evidence on PMV and its outcomes in rural Kenyan ICUs, which suffer from resource limitations and variability in care practices that contribute to poor outcomes. Although international reports demonstrate high rates of mortality and morbidity, and research in SSA has shown that there are systemic variables that challenge PMV efficacy, there have been few reports of PMV outcomes in rural settings such as Tenwek Hospital. This gap is addressed in this study by assessing PMV experiences (mortality, LOS, functional status, QoL, complications) among adults who require ICU care in Tenwek Hospital. By identifying factors associated with poor outcomes, lessons can be learned to shape context-specific interventions that minimise PMV-related morbidity and improve patient outcomes in this poor rural setting.

2.6 Theoretical Framework

This critical study on prolonged mechanical ventilation (PMV) in critically ill adults is grounded in the integration of three complementary models: the Lung Protective Ventilation Theory, the Pathophysiological Model of Ventilator-Induced Lung Injury (VILI), and the Biopsychosocial Model. Such frameworks offer a holistic perspective to explore the clinical, physiologic, and contextual determinants of PMV complications and outcomes, especially in LMICs. The framework helps direct inquiry into how to minimise damage and promote recovery in critically ill patients requiring prolonged mechanical ventilation by connecting mechanical ventilation strategies with patho-physiological injury mechanisms and patient-specific factors.

The Lung Protective Ventilation Theory promotes interventions to reduce lung-induced injury in MV by supporting low tidal volume (4-6 mL/kg of predicted body weight) and an adequate positive end-expiratory pressure (PEEP) to avoid alveolar overdistension and cyclic collapse (Amato et al., 2015). LVT decreases volutrauma (overstretching of the lung leading to injury) risk, and optimal PEEP prevents atelectrauma (repeated opening and closing of the lung) by maintaining constant alveolar recruitment (Fan et al., 2017). Furthermore, the theory emphasises the importance of restricting driving pressure

(<15 cm H2O) applied to the lung to decrease mechanical stress on lung tissue, which is particularly crucial for ARDS patients, one of the most common causes of PMV (Amato et al., 2015). The adoption of synchronised ventilation, in which the ventilator is synchronised with patient effort, reduces asynchrony, often with a lower requirement for sedation, and enhances patient comfort (White et al., 2024). In resource-constrained settings, where more advanced V models with automated modes may not be accessible, the theory still holds. However, implementation is possible by manually setting tidal volume and PEEP to deliver LP (Devlin et al., 2018). It is consistent with the study's purpose to explore ventilator management strategies that limit complications, such as VILI, which can prolong ventilation and worsen outcomes. The theory also promotes evidence-based weaning protocols, such as daily SBTs, which can facilitate readiness for extubation and shorten the duration of PMV (López-Fernández & Fernández, 2024). Weaning Patients should be mobilised early, as this may help prevent loss of respiratory muscle strength, which in turn facilitates weaning and improves outcome (Bissett et al., 2020).

The Pathophysiological Model of VILI describes how improper ventilator settings induce secondary lung injury and subsequently have implications for PMV complications. The mechanisms of VILI can be divided into three main processes: barotrauma, volutrauma, and biotrauma (White et al., 2024). Barotrauma, characterised by high air pressures in the airway leading to the rupture of an alveolus, and its complications, such as pneumothorax or subcutaneous emphysema, may arise (Amato et al., 2015). Volutrauma is caused by high tidal volumes that overdistend and mechanically stress the lungs. Biotrauma is due to the release of inflammatory cytokines that perpetuate systemic inflammation and multi-organ end-organ dysfunction (Oyster, 2025). Patient–ventilator asynchrony, in which patient inspiratory efforts are not matched to ventilator inspiratory cycles, increases lung stress, leading to diaphragm dysfunction and failure to wean (White et al., 2024). There is also muscle atrophy of the respiratory muscles, which can complicate weaning with prolonged ventilation (Bissett et al., 2020). In resource-poor settings, inconsistent monitoring, inadequate ventilator calibration, and the difficulty of providing sedation contribute to the risk of VILI (Thapa et al., 2024). The model facilitates the study by providing a framework for analysing how these mechanisms lead to complications such as infection and organ dysfunction, and how interventions, such as optimal ventilation or early mobilisation, might exert their effects. In this context, protocolized weaning reduces diaphragm inactivity and increases the likelihood of successful weaning (López-Fernández & Fernández, 2024). This aligns with the study's aim to identify complications and their effects on PMV outcomes.

The Biopsychosocial Model complements the pathophysiological approach by incorporating neurobiological, psychological, and social influences on PMV outcomes (Maes et al., 2021). From a biological perspective, comorbidities such as chronic respiratory disease, diabetes, or renal failure compromise both respiratory mechanics and immunity, rendering the host more susceptible to complications (Devlin et al., 2018). From a psychological perspective, over-sedation or delirium can decrease respiratory drive, leading to delayed weaning and prolonged ventilator dependence (Devlin et al., 2018).

Socially, reduced physical and post-ICU rehabilitation support, financial challenges, and a low-income family setup also limit recovery, especially in a low-resource environment (Thapa et al., 2024). In those settings, systemic issues, including under-resourced ICUs, low availability of diagnostic testing, and high burdens of infectious diseases, magnify these issues (Maes et al., 2021). The model also supports multidisciplinary interventions, such as nutritional support to reduce the development of muscle wasting, psychological interventions to treat delirium, and community-based rehabilitation to enhance long-term recovery outcomes (Bissett et al., 2020). This aligns with the study's objective: to investigate the patient-specific and systemic factors that influence weaning success and functional recovery, and to underscore the importance of a customised care plan in low-resource health care settings. These frameworks are integrated into a coherent research framework. The Lung Protective Ventilation Theory gives the framework to rate clinical strategies that might prevent organ injury, including the use of low tidal volume and adjusting PEEP to attenuate complications (Amato et al., 2015).

The Pathophysiological Model of VILI describes the key clinical needs that these complications, such as barotrauma and biotrauma, address, which helps to understand how those might be affecting patient outcomes (Brochard et al., 2017). The Biopsychosocial Model further frames these biological and clinical factors by considering patient-level and societal-level impediments, notably in under-resourced environments (Maes et al., 2021). They support the aims of the study-to-study PMV complications and outcomes by offering a systematic approach to interpreting ventilator management, mechanisms of complications, and patient recovery.

The Lung Protective Ventilation Theory has influenced worldwide clinical practice guidelines for the treatment of critically ill patients who require PMV. Small tidal volumes decrease the strain exerted on alveoli, protect against volutrauma, and shorten the ventilation time (Fan et al., 2018). Optimal PEEP can preserve lung compliance and attenuate the cyclic collapse-related biotrauma (Amato et al., 2015). Synchronised ventilation decreases asynchrony, facilitates patient-ventilator interaction, and reduces the need for sedatives (Brochard et al., 2017). In resource-limited settings where ventilators may lack sophisticated features, manual tidal volume and PEEP settings can still achieve lung protection (Devlin et al., 2018). This type of weaning, based on protocols, as the SBTs do, results in earlier patient extubation and lower risk of complications (López-Fernández & Fernández, 2024). Early mobilisation prevents respiratory muscle atrophy, thereby easing weaning and enhancing functional recovery (Bissett et al., 2020). These approaches are very important for the focus of our study on the appropriate management of MV to decrease PMV comorbidities.

The Pathophysiological Model of VILI explains how mechanical ventilation can damage lung parenchyma, especially after prolonged use. High airway pressures result in barotrauma, with alveolar disruption and sequelae such as pneumothorax (Amato et al., 2015). High tidal volumes lead to volutrauma, which involves mechanical forces and inflammation (Fan et al., 2018). Biotrauma increases systemic inflammation, leading to multi-organ dysfunction and enduring mechanical ventilation (Brochard et al., 2017).

Muscle weakness/ Paralysis of the diaphragm from prolonged inactivity and/or oversedation further complicates the weaning process, leading to increased ICU length of stay (LOS) (Bissett et al., 2020). In low-resource settings, the paucity of diagnostic tools to detect early VILI and poor ventilator service put these risks at extremely high levels (Thapa et al., 2024). In addition, the model endorses the study by highlighting the importance of monitoring barotrauma and biotrauma-related complications and implementing interventions, such as optimal ventilator settings and weaning protocols, to reduce them (López-Fernández & Fernández, 2024).

The Biopsychosocial Model considers the full scope of PMV results. From a biological perspective, comorbidities reduce lung and immune function and increase the likelihood of complications (Maes et al., 2021). On a psychological level, delirium associated with sedation hinders patient cooperation, which in turn prolongs weaning time (Devlin et al., 2018). Socially, restricted rehabilitation availability and economic limitations impede recovery, especially in resource-poor settings where post-ICU care is limited (Thapa et al., 2024). The model of care promotes a more comprehensive approach, including addressing nutritional needs to prevent muscle wasting, psychological management to alleviate delirium, and community-based rehabilitation to optimise long-term outcomes (Bissett et al., 2020). This aligns with the study's objectives: to determine the impact of patient-related and systemic factors on PMV outcomes and to drive the development of targeted interventions.

The frameworks also support the approach taken in this study by establishing links among clinical, physiological, and contextual domains. The Lung Protective Ventilation Concept directs the assessment of ventilator management strategies to minimise adverse events (Amato et al., 2015). Then, it is possible to interpret the physiological mechanisms involved in complications in terms of their prevalence and consequences through the lens of the VILI Model (Brochard et al., 2017). The Biopsychosocial Model also incorporates patient-level and systemic factors, including comorbidities and recovery resources, when examining outcomes such as weaning success and functional recovery (Maes et al., 2021).

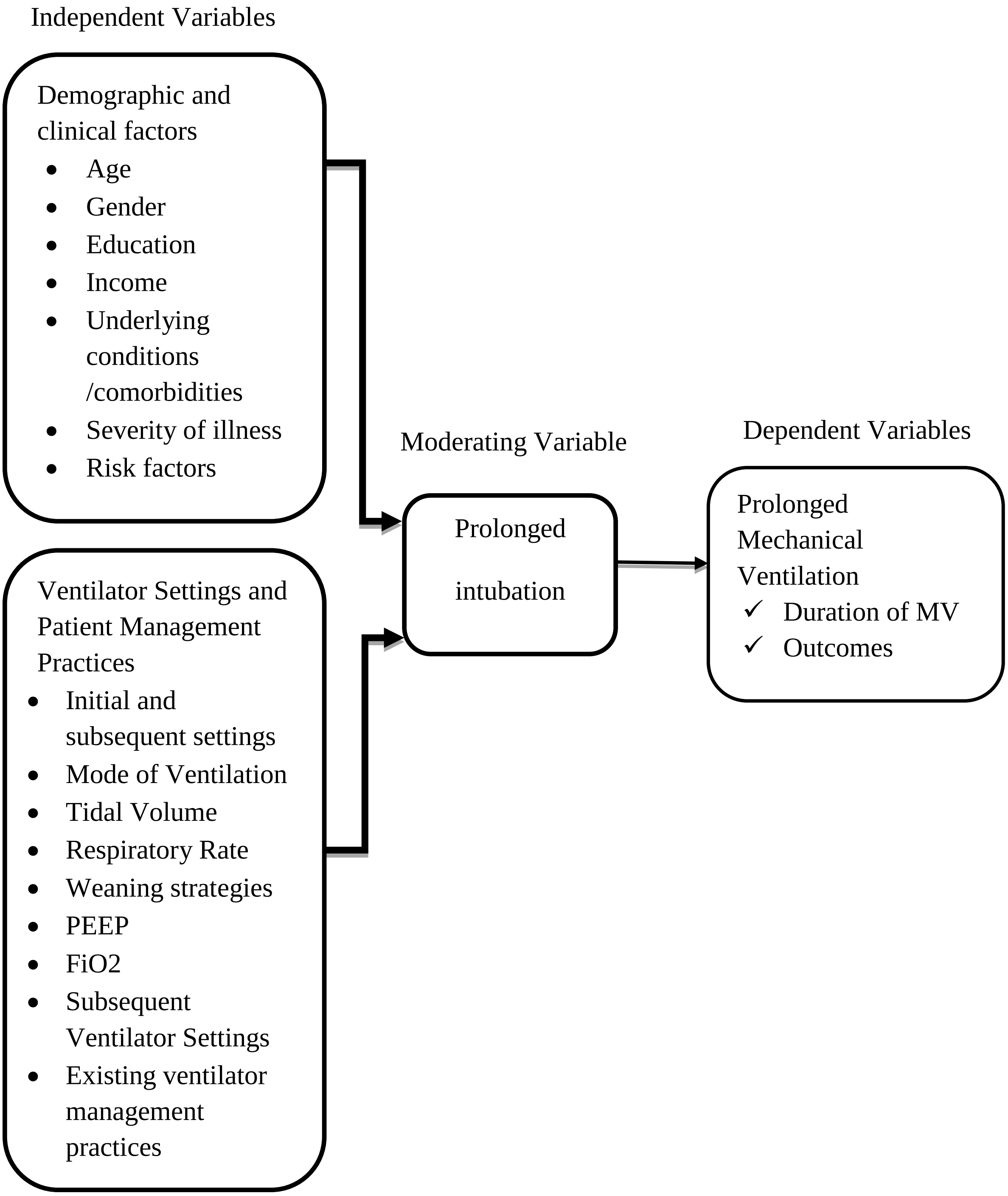
In low-resource settings, these frameworks emphasise operational tweaks, including manual ventilator settings, low-cost weaning protocols, and the management of socioeconomic barriers to the implementation of PMV applications (Thapa et al., 2024). This conceptual framework contributes to the study by outlining a systematic approach to examining PMV complications and outcomes. The Lung Protective Ventilation Theory focuses on preventing lung damage in clinical settings.

The VILI Model is the clinical sequel and is based on pathophysiology, while the Biopsychosocial Model puts the preceding into the context of the patient and the environment. They address the study aims by informing ventilator management, mechanisms of complications, and patient recovery, including for resource-constrained settings where these challenges are exacerbated.

2.7 Conceptual Framework

Figure 1

Conceptual Framework



Source: Author’s own conceptualisation

The conceptual framework for this study explores the relationship between various independent variables, such as demographic characteristics (age, sex, education, and comorbidities), clinical risk factors (illness severity, organ failure, level of consciousness), and ventilator management practices (ventilator settings, sedation use, weaning protocols), and the outcome of prolonged mechanical ventilation. These relationships are influenced by modifying variables, including healthcare infrastructure, institutional guidelines, and socioeconomic or cultural factors, which may alter the impact or expression of the primary variables. The dependent variable, prolonged mechanical ventilation, is defined as the need for mechanical ventilation beyond a typical duration (e.g., more than 7), and understanding these interconnected elements is essential for improving patient outcomes and optimising ICU care strategies.

CHAPTER THREE

RESEARCH METHODOLOGY

3.1 Introduction

This Chapter presents a comprehensive overview of the research design, study population, sampling procedure, sample size, pilot study, instrument validity and reliability, data collection procedure, and data analysis. It provides a detailed roadmap of how the study was conducted and offers readers a clear understanding of the methodological foundations underpinning it.

3.2 Research Design

This study employed a retrospective cohort design to evaluate the prevalence, clinical predictors, and outcomes of prolonged mechanical ventilation among adult patients in the critical care unit of Tenwek Hospital, Bomet County, Kenya. Historical data were extracted from medical records to compare patients who underwent prolonged mechanical ventilation with those ventilated for shorter durations. The analysis focused on identifying patient characteristics and management strategies associated with PMV, as well as examining clinical outcomes, including complications, ICU length of stay, and mortality.

3.3 Location of the Study

The study was conducted at Tenwek Hospital. The institution was established in 1937 and is located in Bomet County. Tenwek Hospital is the Medical Ministry of the Africa Gospel Church in collaboration with the World Gospel Mission. It has a 361-bed capacity and falls under the Level 6(b), Teaching and Referral Mission Hospital category. The hospital serves the needs of the Southwest region of Kenya and the country at large.

The institution was chosen as a suitable location for the study because it receives many patients with various conditions requiring ICU care. The facility is well equipped with two (2) modern intensive care units, ICUs A and B, with a bed capacity of six and seven, respectively. Specialised nurses primarily staff the unit. Admission of patients is overseen by consultants from the respective departments: obstetrics and gynaecology, medical, surgical, neurosurgery, orthopaedics, or paediatrics. Each team reviews its patients since there is no intensivist. Tenwek Hospital does not have a dedicated pediatric critical care unit, so pediatric patients use the unit as well.

3.4 Study Population

The study population comprised adult patients admitted to the intensive care unit (ICU) at Tenwek Hospital, Bomet County, Kenya, who required invasive mechanical ventilation (MV) during their hospital stay. A total of 173 patient records were retrospectively reviewed, covering admissions between January and December 2024.

Within this cohort, patients who remained on mechanical ventilation for more than seven days were classified as the exposed group (prolonged mechanical ventilation, PMV), while those ventilated for fewer than seven days formed the comparison group. This classification allowed for systematic evaluation of the prevalence, clinical predictors, and outcomes associated with PMV, including complications, length of ICU stay, and mortality.

3.5 Sampling Method

A convenience sampling technique was used to estimate the number of ICU patients at Tenwek Hospital. This method included all patients admitted to the ICU who met the inclusion criterion of being on mechanical ventilation, and the data were collected retrospectively from medical records from January to December. Convenience sampling was used because of the pragmatic need to access a full patient population in a limited-resource environment and because documented cases in the hospital database were available as the study datasets. This approach enabled the collection of a representative sample of ICU patients with a history of prolonged mechanical ventilation (>21 days).

3.6 Sampling Procedure

After approval by the institutional scientific research and ethics committee, the researcher liaised with Tenwek Hospital's administration to access the required patient records, while ensuring compliance with data privacy and confidentiality regulations. Data were collected from electronic medical records (EMRs) and ICU databases at Tenwek Hospital. A list of patients managed in the ICU was generated, and the database was used to filter it.

Next, the researcher reviewed each patient record in the filtered list to determine whether it met the study's specific inclusion criteria. These criteria might include mechanically ventilated patients, patients with an endotracheal tube in place for more than 21 days, or patients with complete and available medical records. Records that do not meet the criteria were skipped. As the researcher proceeds through the list sequentially (consecutively), every eligible patient record is included in the sample until the target sample size is reached. This method minimizes selection bias by excluding records only when they meet the inclusion criteria.

Consecutive sampling is instrumental in retrospective studies, where researchers are limited to existing data and need a practical method for obtaining a representative sample without random selection. While it does not guarantee full generalizability like probability sampling, it does provide a logical and consistent approach to sample selection in real-world clinical research. Records were prioritised based on completeness and relevance to the study objectives. One hundred fifty-six eligible records were selected to ensure manageability. The number of records obtained was documented, and the researcher proceeded with the available data.

3.6.1 Inclusion Criteria

Patients aged 18 years or older admitted to the ICU from January to December 2024 were included in the study. Only those who received MV support during their ICU stay were selected.

3.6.2 Exclusion Criteria

Patients were excluded if they were:

i. < 18 years (paediatric cases), or
ii. had incomplete or missing medical records, thereby preventing a reliable determination of ventilation duration or predictor variables.

3.7 Sample Size

This study examined all patients admitted to the ICU at Tenwek Hospital who required mechanical ventilation during January to December 2024. One hundred seventy-three eligible cases were incorporated. The study employed a census method rather than sampling because all eligible patients during the study period were included.

Census sampling applies when the entire target population is available and relatively small, allowing researchers to cover all eligible individuals and eliminating the need for statistical estimation. This is a common approach in health research when boundaries are clear, and participants can be effectively managed (Latpate et al., 2021).

3.8 Research Instruments

Since this study utilised archived patient records, a structured data extraction tool was used to collect and document relevant clinical information systematically. This tool was specifically developed to extract data from the medical records of patients admitted to the critical care unit at Tenwek Hospital who received mechanical ventilation (MV) support between January and December 2024. The tool was designed to ensure uniformity and accuracy in capturing various clinical and demographic variables pertinent to the study objectives.

The first data category collected was the prevalence of prolonged mechanical ventilation. This included documentation of the duration of intubation in days and the exact dates of MV initiation and cessation. From this information, each case was categorised as prolonged mechanical ventilation (lasting more than 7 days) or non-prolonged mechanical ventilation. This enabled the calculation of the general prevalence of protracted mechanical ventilation among mechanically ventilated patients during this period.

The second data collection included data on patient demographics and clinical risk factors. This comprised age, sex, admission diagnosis, and pre-morbid comorbid diseases such as hypertension, diabetes mellitus, COPD, and immunosuppression-metabolic state. Other information was nutritional status (e.g., Body Mass Index), severity of illness, time of data availability, and APACHE II score. Such information is crucial in building evidence on the features and risk factors of prolonged mechanical ventilation.

The third section collected information on ventilator settings and ventilator management. The latter may include the mode of ventilation initiated and specific basic ventilator settings comprising tidal volume, FiO_2, PEEP, and respiratory rate. The tool also described the use of sedation, neuromuscular blockade, prone positioning, recruitment manoeuvres, and the protocol and weaning practices, including SBTs. These findings were important in determining whether ventilator management strategies are associated with intubation duration.

Finally, information on complications and clinical outcomes was recorded. These included ventilator-associated pneumonia (VAP), barotrauma, and the need for tracheostomy. In addition to documenting their presence, the time-to-occurrence of each complication was analysed using survival methods, allowing estimation of hazard ratios and confidence intervals for risk factors associated with earlier or later onset. Additional endpoints included ICU and hospital length of stay, survival or death status, and assessment of neurologic function at discharge. Together, these outcomes illustrated the clinical implications of prolonged mechanical ventilation at both the individual patient level and the wider ICU system.

3.9 Validity and Reliability of the Instrument

3.9.1 Validity of the Instrument

The validity of a research instrument is the extent to which an instrument measures what it is supposed to measure (Peeters & Harpe, 2022). It also ensures that interpretations of the data are safe, trustworthy, and aligned with the research's purpose. The data extraction tool was constructed with clinicians in the ICU delivering care to patients on mechanical ventilation, to assess its validity and clinical applicability. Moreover, to enhance diagnostic precision, all recorded diagnoses were confirmed using standardised classification systems, including the International Classification of Diseases (ICD), and a physician or intensivist was consulted to verify the accuracy of the information in patients' records.

The data included patient demographics (age, sex, and comorbid conditions), primary and secondary diagnoses, reasons for ICU admission, duration, and mode of mechanical ventilation, necessary ventilator controls (e.g., tidal volume, respiratory rate, FiO_2 , PEEP), pertinent laboratory findings, adverse events during the ICU period (e.g., ventilator-associated pneumonia, sepsis, organ dysfunction), drugs given (e.g., sedatives, antibiotics, vasopressors), and details on important clinical outcomes, such as duration of ICU stay, survival status, and discharge status. In addition, the design of the data collection instrument was informed by an extensive review of the literature on mechanical ventilation and prolonged mechanical ventilation practices, to ensure compatibility with well-established research methods and maximise comparability between studies.

3.9.2 Reliability of the Instrument

The reliability of a research instrument refers to its capacity to yield consistent or similar results when applied repeatedly under the same conditions (Stage & Kilmartin, 2025). In this study, reliability was closely related to the accuracy and consistency of data abstraction from patient records. To ensure this, a random sample of charts was independently reviewed by two investigators. This process allowed assessment of whether both reviewers extracted similar information for each variable, particularly for less straightforward measures such as ventilator settings and clinical complications.

Quantitative reliability was evaluated using Cohen's Kappa statistic for categorical variables (e.g., presence of ventilator-associated pneumonia, comorbidity classification) and the intraclass correlation coefficient (ICC) for continuous variables (e.g., duration of intubation, ventilator parameters). These measures provided evidence of agreement beyond chance and consistency across raters, which is critical for complex variables where interpretations may vary.

In addition, a pilot study of the PMV-DAT was conducted at AIC Litein Hospital (a faith-based hospital with a setup similar to Tenwek Hospital) to evaluate feasibility and efficacy. The pilot, representing 10% of the estimated sample size, was recruited from ICU records describing a comparable patient profile (e.g., respiratory failure, comorbidities). The pilot was implemented shortly after approval by the Kabarak

University Institutional Research Ethics Committee (KUREC) and authorisation from NACOSTI, facilitating timely revisions before complete data collection.

The tool was tested for its capacity to capture essential variables reliably and to harmonise definitions where possible, leading to adjustments (e.g., refining ventilatory-setting definitions and regrouping outcome categories). The instrument's internal consistency, as measured by Cronbach's alpha, was 0.724, indicating acceptable reliability for this study.

3.10 Data Collection Procedure

After obtaining consent from the Institutional Research and Ethics Committee and the Kabarak University Research Ethics Committee (KUREC), a structured data extraction tool was used to systematically collect information from patient records. This enabled documentation of the full range of factors across several important categories, including patient demographics, admission information, comorbidities, intubation and extubation events, vital signs, ventilator settings, and discharge disposition.

Data were entered directly into the tool to reduce errors and ensure accuracy. Inconsistencies or discrepancies found in the review above were immediately corrected and maintained to avoid future mistakes.

3.11 Data Analysis

Following data collection from patient records, the data underwent a thorough cleaning process to identify and address inconsistencies, outliers, and missing values. SPSS version 30 was used for data entry, management, and statistical analysis. The cleaned and verified dataset was securely stored and backed up to ensure data integrity and confidentiality throughout the study. Descriptive statistics were employed, including mean, median, standard deviation, and interquartile range for continuous variables (e.g., age, MV period). Categorical variables (e.g., pre-existing conditions, re-intubation done, etc.) were summarised using frequencies and percentages.

Chi-square statistics were used to examine the relationship between demographic and clinical factors and PMV. Logistic regression was used to identify predictors of PMV (e.g., ARDS, COPD). The Cox proportional hazards model was used to assess the association between time to extubation and mortality risk. Multivariate logistic regression was employed to explore the determinants of PMV. The outcome variable was the occurrence of PMV, defined as mechanical ventilation lasting more than 7 days. Predictor variables were selected using a p-value-based approach, guided by clinical relevance and evidence from the literature. A cut-off p-value of 0.05 was used to determine statistical significance. Regression coefficients were exponentiated to produce odds ratios (ORs), reflecting the strength and direction of each predictor's association with prolonged mechanical ventilation (PMV). The commonly accepted rule of thumb, a minimum of 10 events per predictor variable, was applied to ensure model stability and avoid under-fitting. A sensitivity analysis was incorporated to test the robustness of the logistic regression model by examining how results change when key assumptions or inclusion criteria are varied

3.11.1 Analytical Approaches per Research Objective

All descriptive statistics were produced with IBM SPSS version 27, while every inferential model (logistic regression for Objectives 2 and 3; Cox proportional-hazards for Objective 4; prevalence confidence interval for Objective 1) was fitted and validated in Python 3.10 using the statsmodels, lifelines, and scipy-stats libraries to guarantee transparency and reproducibility (Nguyen et al., 2023).

Objective 1: Prevalence of prolonged mechanical ventilation (> 7 days)

Prevalence was estimated as a simple proportion with a 95 % Wilson-Score confidence interval, the method recommended when the outcome is binary, and the sample size is moderate (Agresti & Coull, 1998).

$$\hat{p} = \frac{x}{n}; \quad 95\%\text{CI} = \hat{p} \pm z_{1-\alpha/2}\sqrt{\frac{\hat{p}(1-\hat{p})}{n}} \quad \text{...4}$$

where x = 125 cases with PMV and n = 173.

Objective 2: Clinical risk factors for prolonged mechanical ventilation

A multivariable logistic regression was fitted to obtain adjusted odds ratios (OR). The binary outcome Y (1 = PMV > 7 days, 0 = ≤ 7 days) was modelled as

$$logit(P) = ln(1-PP) = \beta 0 + \beta 1(ARDS) + \beta 2(COPD) + \cdots + \beta k(APACHE\ II) \quad \text{...5}$$

Logistic regression is the gold standard for retrospective cohorts with dichotomous outcomes because it directly estimates the OR and handles both continuous and categorical predictors (Hosmer et al., 2013). Variable selection followed the purposeful conceptual framework described by Sun et al. (2023) to satisfy the 10 events-per-predictor rule (Peduzzi et al., 1996). Model fit was assessed with the Hosmer-Lemeshow test and pseudo-R^2.

Objective 3: Effect of ventilator & patient-management practices on intubation duration

A second logistic model was fitted with three management predictors: daily sedation vacation, early-mobility protocol, and sedation use. The choice of the same binary outcome preserved comparability while the smaller predictor set ensured model stability

(Heinze & Dunkler, 2017). The binary outcome Y (1 = prolonged mechanical ventilation > 7 days, 0 = ≤ 7 days) was modelled as:

$$logit[P(Y=1|\ X)] = \beta 0 + \beta 1(Daily\ Sedation\ Vacation) + \beta 2(Early\ Mobility\ Protocol) + \beta 3(Sedation\ Used) \quad \ldots 6$$

Where β_1, β_2, and β_3 denote the adjusted log-odds ratios for each management predictor.

Objective 4: Outcomes Related to Prolonged Mechanical Ventilation

A Cox proportional-hazards (PH) model was used to estimate the hazard ratios (HRs) for the time-to-extubation event. The model is

$$h_0(t|\ \mathbf{X}) = h_0(t)\, exp(\beta 1X1 + \cdots + \beta pXp) \quad \ldots 7$$

Where $h_0(t)$ is the baseline hazard, and X represents covariates such as disease-severity tier and age group. The Cox PH model is preferred for retrospective time-to-event data with censoring (Keret & Gorfine, 2023). The Schoenfeld residuals test confirmed the PH assumption ($p > 0.05$).

3.12 Ethical Considerations

This study involves a retrospective review of archived patient records, posing minimal risk to participants, as there was no direct patient contact or interventions. The primary aim of this study is to determine the prevalence, associated factors, and outcomes of PMV among patients admitted to the critical care unit at Tenwek Hospital. The findings from this study are expected to contribute to clinical practice by enhancing patient care protocols and informing strategies for the management of patients requiring mechanical ventilation.

In line with ethical principles, the study upheld patient privacy and confidentiality. No personally identifiable information was collected from the patient records. All extracted data was anonymised by assigning unique identifiers to each patient’s record, thereby safeguarding their identity. Anonymised data were password-protected on the computer to avoid unauthorised access. In addition, all data were processed in accordance with the relevant laws and guidelines on data privacy and confidentiality in research.

As this is a retrospective study, written informed consent from patients is unavailable. The researcher therefore applied for an exemption from obtaining permission from the Tenwek Hospital Institutional Scientific Research and Ethics Committee (ISREC). This waiver is customary for retrospective chart reviews, where the data are de-identified, and there is no direct interaction with participants. The waiver would allow for the enforcement of ethical considerations without placing a great demand on the patient or their family.

The study was reviewed and approved by both Tenwek Hospital ISREC and Kabarak University Research Ethical Committee (KUREC) to ensure compliance with all ethical standards for research involving human subjects. This comprised a review of the study protocol, data management, confidentiality, and privacy issues. The low risk to subjects is offset by the potential to learn important lessons to help manage mechanically ventilated patients, ultimately improving the clinical outcomes of ICU patients and their care. By examining factors associated with prolonged endotracheal intubation, this study could provide evidence to support optimal decision-making in ventilator management and minimise complications of prolonged mechanical ventilation, ultimately contributing to better patient care.

CHAPTER FOUR

DATA ANALYSIS, PRESENTATIONS AND DICUSSIONS

4.1 Introduction

This chapter presents the study's results. Those data were obtained by analysing data from 173 respondents at Tenwek Hospital. The chapter is structured around four objectives: the description of the demographic and clinical characteristics of the cohort; the occurrence of prolonged mechanical ventilation and its associated risk factors; the impact of both ventilator and patient management; and an insight into the outcomes of prolonged ventilation. Descriptive statistics, inferential analyses, and graphical representations are included in all subsections to assist the readers in understanding the implications of changes.

4.2 Demographic Analysis

This section considers the 173 ICU patients whose records were reviewed. It describes the distribution of patients by sex, educational level, and age group, and provides the socio-demographic context in which prolonged mechanical ventilation occurred. The findings are described in Figure 2, which shows the frequency and proportion by gender. The sample was predominantly male, with 127 respondents (73.4%) compared to 46 females (26.6%). This indicates a male-biased sample distribution (Figure 2).

4.1.1 Education Level Distribution of ICU Respondents

To provide a complete overview of the demographic characteristics of ICU participants, the distribution of respondents' education levels was presented. Table 1 shows the frequency and percentage distribution of the sample by the highest level of education completed.

Table 1

Education Level Distribution of ICU Respondents

Education Level	Frequency	Percent
No Formal Education	1	0.6
Primary	70	40.5
Secondary	58	33.5
Tertiary	44	25.4
Total	173	100.0

Table 1 shows the education level distribution of ICU patients at Tenwek Hospital. Most patients had primary education, followed closely by secondary and tertiary education. A small minority had no formal education.

4.1.2 Age Distribution of ICU Respondents

Table 2 presents the age distribution of ICU patients at Tenwek Hospital.

Table 2

Age Distribution of ICU Respondents

Age	Frequency	Percent
28-39 years	4	2.3
40-59 years	39	22.5
60-79 years	82	47.4
80-100 years	48	27.7
Total	173	100.0

Table 2 presents the age distribution of ICU patients at Tenwek Hospital. Nearly half (n = 82; 47.4%) were aged 60–79, while 48 (27.7%) were aged 80–100. A smaller proportion (n = 39; 22.5%) were aged 40–59, and only four (2.3%) were aged 28–39.

4.3 Descriptive Statistics of Clinical Conditions

Table 3 presents secondary diagnoses and comorbidities of ICU patients at Tenwek Hospital.

Table 3

Prevalence of Clinical Conditions and Comorbidities Among ICU Patients

	Condition	Frequency	Percent
Secondary Diagnosis	AKI	6	3.5
	Pneumonia	27	15.6
	Sepsis	15	8.7
	Total	48	27.7
Presence of ARDS	No	59	34.1
	Yes	114	65.9
	Total	173	100.0
Presence of Sepsis	No	57	32.9
	Yes	116	67.1
	Total	173	100.0
Presence of Pneumonia	No	95	54.9
	Yes	78	45.1
	Total	173	100.0
COPD	No	48	27.7
	Yes	125	72.3
	Total	173	100.0
Heart Failure	No	88	50.9
	Yes	85	49.1
	Total	173	100.0
Diabetes	No	55	31.8
	Yes	118	68.2
	Total	173	100.0
CKD	No	69	39.9
	Yes	104	60.1
	Total	173	100.0
Others	Yes (AKI)	28	16.2

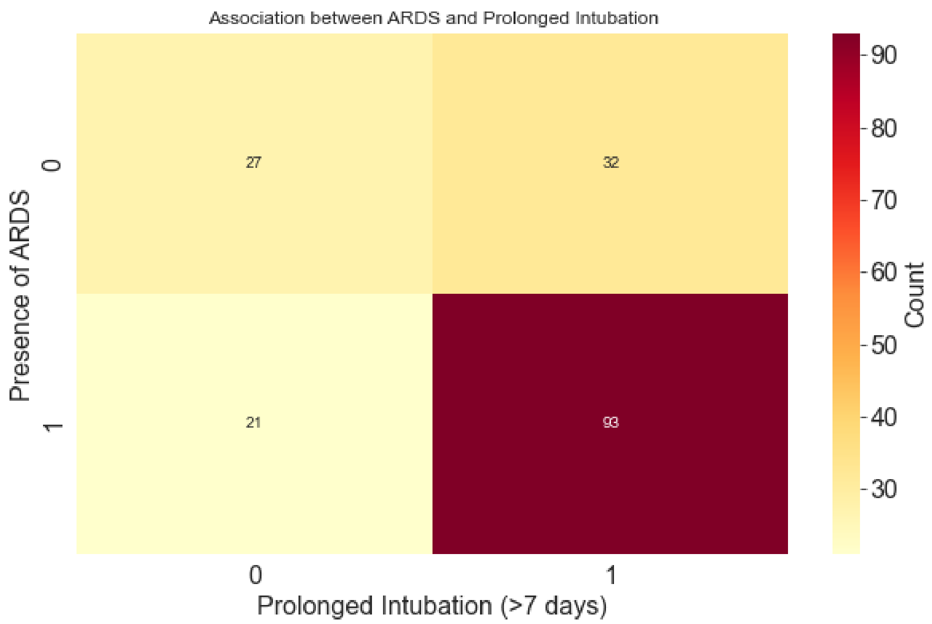
Among secondary diagnoses, pneumonia was the most prevalent (n = 27; 15.6%), followed by sepsis (n = 15; 8.7%) and AKI (n = 6; 3.5%), with 27.7% (n = 48) having at least one secondary diagnosis. Among comorbidities, COPD (n = 125; 72.3%), diabetes (n = 118; 68.2%), and ARDS (n = 114; 65.9%) were most common, followed by CKD (n = 104; 60.1%) and heart failure (n = 85; 49.1%).

4.3.1 Association between ARDS and Prolonged Mechanical Ventilation

The visual representation in Figure 2 illustrates the association between acute respiratory distress syndrome (ARDS) and prolonged mechanical ventilation among ICU patients.

Figure 2

Association between ARDS and Prolonged Mechanical Ventilation



The results show that 32 patients did not have ARDS and did not experience prolonged mechanical ventilation. Conversely, 27 patients developed ARDS but did not have prolonged mechanical ventilation. The quadrant with the highest number of patients is the one indicating those with ARDS and prolonged mechanical ventilation, with 98 patients. Most patients with ARDS had PMV (n = 98; 56.6%), whereas fewer patients without ARDS had PMV (n = 21; 12.1%). A chi-square test of independence was conducted, revealing a significant association between ARDS and PMV ($p < 0.05$).

4.4 Descriptive Statistics of Ventilator Management Practices

The descriptive statistics in Table 4 provide insights into the ventilator management practices used among ICU patients. This information is essential for understanding the standard of care in the critical care setting and for evaluating adherence to recommended protocols. The results encompass various aspects of ventilator management, including sedation use, sedation type, daily sedation vacation, early mobility protocol, ventilator mode used after initial stabilisation, prolonged mechanical ventilation, reintubation, tracheostomy, and ventilator-associated pneumonia (VAP).

Table 4

Distribution of Ventilator Management Practices Among ICU Patients

	Condition	Frequency	Percent
Sedation Used	No	21	12.1
	Yes	152	87.9
	Total	173	100.0
Sedation Type	Midazolam	86	49.7
	Propofol	87	50.3
	Total	173	100.0
Daily Sedation Vacation	No	52	30.1
	Yes	121	69.9
	Total	173	100.0
Early Mobility Protocol	No	85	49.1
	Yes	88	50.9
	Total	173	100.0
Subsequent Mode	CPAP	80	46.2
	PSV	93	53.8
	Total	173	100.0
Prolonged mechanical ventilation (>7 days)	No	48	27.7
	Yes	125	72.3
	Total	173	100.0
Reintubation	No	120	69.4
	Yes	53	30.6
	Total	173	100.0
Tracheostomy	No	113	65.3
	Yes	60	34.7
	Total	173	100.0
VAP	No	117	67.6
	Yes	56	32.4
	Total	173	100.0

Most patients received sedation (n = 152; 87.9%), with Propofol used slightly more often (n = 87; 50.3%) than Midazolam (n = 86; 49.7%). Daily sedation vacation was typical (n = 121; 69.9%), and PMV (>7 days) occurred in the majority of cases (n = 125; 72.3%).

Pressure Support Ventilation (PSV) was the preferred subsequent mode (n = 93; 53.8%), while reintubation (n = 53; 30.6%) and VAP (n = 56; 32.4%) were less frequent.

4.5 Descriptive Statistics of Outcomes

Table 5 presents the outcomes for 173 ICU patients at Tenwek Hospital, including mortality and Survival Rates.

Table 5

ICU Patient Outcomes: Mortality and Survival Rates

	Frequency	Percent
Mortality	121	69.9
Survival	52	30.1
Total	173	100.0

The majority experienced mortality (n = 121; 69.9%), while fewer survived (n = 52; 30.1%). Table 6 presents descriptive statistics for 173 ICU patients at Tenwek Hospital.

Table 6

Summary of Descriptive Statistics for ICU Patient Cohort (n = 173)

Statistic	Age	APACHE II Score	Tidal Volume (mL)	PEEP (cm H_2O)	FiO_1 (%)	MV Duration (days)	ICU LOS (days)	Hospital LOS (days)
Count	173	173	173	173	173	173	173	173
Mean	71	23.46	452.97	7.23	61.11	8.03	12.65	22.08
Std	16	7.72	52.66	2.14	18.15	4	6.6	9.95
Min	28	5	337	5	30	1	1	1
25%	60	18	412	5	47	5	9	15
Median	71	24	451	7	61	8	12	22
75%	83	28	494	8	75	11	17	29
Max	100	43	588	14	100	17	32	50

Table 6 presents the measures of central tendency and dispersion for age, APACHE II score, ventilator settings (tidal volume, PEEP, FiO2), duration of mechanical ventilation, ICU length of stay, and hospital length of stay. The number of variables, along with their means, standard deviations, minimums, maximums, and interquantile ranges (25th, 50th, and 75th percentiles), are reported. These values present a detailed description of the clinical and management features of the cohort.

4.6 Tests for Model Assumptions

Before undertaking parametric analyses, the study assessed the distributional characteristics of the continuous variables using the Shapiro-Wilk test. Normality is a fundamental assumption for many inferential techniques. Table 7 reports the test statistics and corresponding p-values for Age, APACHE II Score, Tidal Volume, and Hospital Length of Stay among the 173 ICU patients.

Table 7

Shapiro-Wilk Test for Normality of Continuous Variables (Variable type: continuous, n = 173)

Variable	Shapiro-Wilk Statistic	p-value	Interpretation
Age	0.987	0.098	Normally distributed ($p \geq 0.05$)
APACHE II Score	0.995	0.804	Normally distributed ($p \geq 0.05$)
Tidal Volume (mL)	0.992	0.488	Normally distributed ($p \geq 0.05$)
Hospital LOS (days)	0.993	0.524	Normally distributed ($p \geq 0.05$)

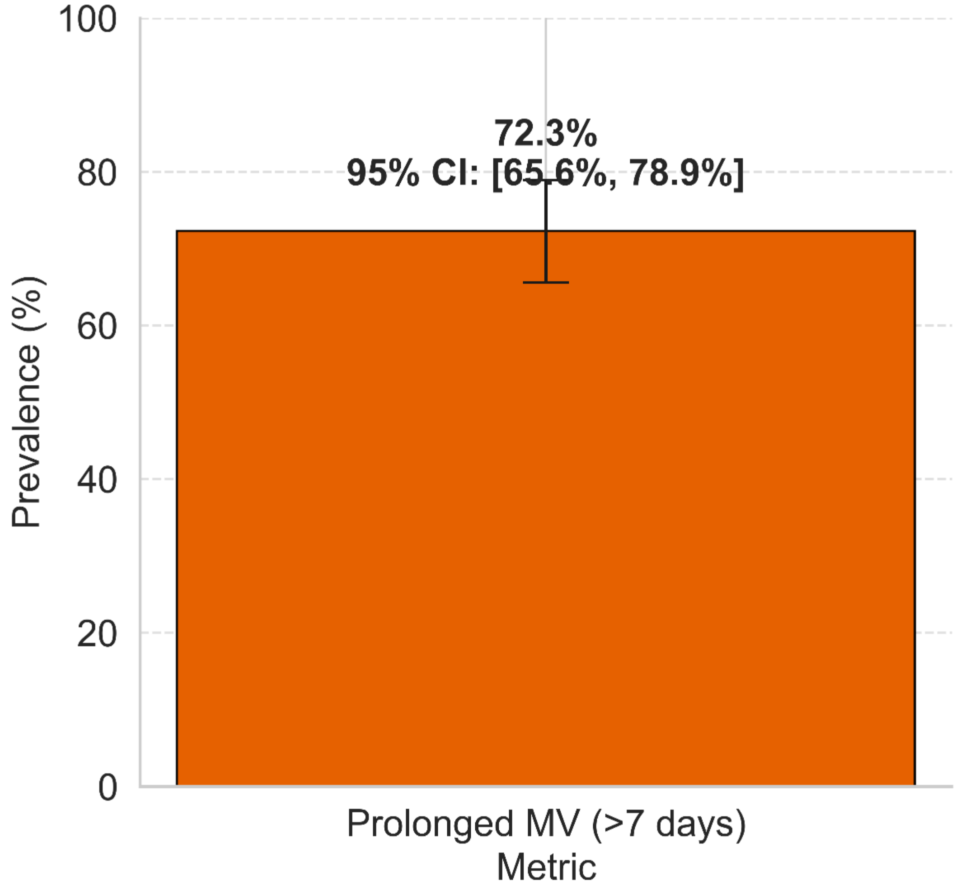
Given that Age, APACHE II Score, Tidal Volume, and Hospital LOS satisfied the normality assumption, parametric tests were deemed appropriate for further inferential analyses.

4.7 Prevalence of Prolonged Mechanical Ventilation

The prevalence of prolonged mechanical ventilation among ICU patients at Tenwek Hospital was examined. Figure 3 shows the prevalence of prolonged mechanical ventilation (PMV) among ICU patients at Tenwek Hospital. The bar chart illustrates the proportion of patients who experienced PMV, defined as mechanical ventilation lasting more than seven days. This graphical depiction quantifies the extent to which PMV is a common occurrence in the ICU setting.

Figure 3

Prevalence of Prolonged Mechanical Ventilation (>7 days) in ICU Patients



The figure established that 72.3% of ICU participants had PMV. This percentage is indicated on the graph by the six-error bar, which represents the 95% confidence interval (65.6-78.9%).

4.8 Demographic and Clinical Risk Factors Contributing to Prolonged Mechanical Ventilation in ICU Patients

The second objective of the study was to identify demographic and clinical risk factors associated with prolonged mechanical ventilation (PMV) among ICU patients at Tenwek Hospital. Table 8 presents the logistic regression results for clinical predictors of PMV. Odds ratios (ORs) with 95% confidence intervals (CIs) were obtained by maximum likelihood estimation to approximate the strength of association between each risk factor and PMV. Reporting CIs, in addition to ORs, provides a more informative measure of precision and effect size than $p_2$values alone, consistent with ongoing debates in epidemiology regarding inference based on $p_2$values.

Table 8

Logistic Regression: Clinical Predictors of Prolonged Mechanical Ventilation

Predictor	Reference Group	Odds Ratio (OR)	95% CI	p-value
Intercept	–	0.045	0.007–0.289	0.019
ARDS	No ARDS	5.245	2.412–11.401	
Sepsis	No Sepsis	1.564	0.693–3.528	0.284
Pneumonia	No Pneumonia	1.819	0.789–4.195	0.160
COPD	No COPD	5.282	2.317–12.041	
Heart Failure	No HF	1.157	0.521–2.569	0.711
Diabetes	No Diabetes	1.092	0.482–2.474	0.834
CKD	No CKD	0.975	0.401–2.371	0.952
APACHE II Score	Per unit	1.038	0.986–1.093	0.154
Age	Per year	1.007	0.976–1.039	0.639

Model Fit Metrics
Dependent Variable: Prolonged Mechanical Ventilation (>7 days)
Method: Maximum Likelihood Estimation (MLE)
Observations: 173
Degrees of Freedom (Model): 9
Degrees of Freedom (Residual): 163
Log-Likelihood: –82.901
LL-Null: –102.160
Pseudo R^2: 0.1885
Likelihood Ratio Test: $p < 0.001$
Model Converged: Yes
Covariance Type: Robust (HC0)

Logistic regression identified ARDS and COPD as statistically significant predictors of prolonged mechanical ventilation, each associated with markedly increased odds (OR > 5, 95% CI excluding 1). Other variables, including pneumonia, sepsis, APACHE II score, age, heart failure, diabetes, and CKD, did not reach statistical significance, which may reflect limited direct effects on ventilatory duration or confounding influences such as age and comorbidity burden. While CKD remains clinically relevant, its impact may be indirect or context-dependent, making it less strongly predictive of PMV in this sample.

The model demonstrated acceptable fit (pseudo $R^2 = 0.1885$; likelihood-ratio test, $p < 0.001$) and employed robust standard errors to enhance reliability. By reporting confidence intervals alongside odds ratios, this analysis provides a more nuanced understanding of effect size and precision, moving beyond reliance on p-values alone.

4.9 Evaluation of Ventilator and Patient Management Practices and Their Clinical Effect on The Duration of Intubation Among ICU Patients

The third objective of the study was to determine whether ventilator and patient management practices, and their clinical impact, influenced the duration of intubation in the ICU at TH. Table 9 presents logistic regression findings on the effects of ventilator and patient management techniques on the duration of intubation in ICU patients. This step is essential to developing and testing management strategies that may reduce the proportion of patients intubated for more than 7 days and, thus, improve patient outcomes. The ORs shown in the table quantify the association between each manipulation and the targeted outcome: prolonged invasive mechanical ventilation (lasting more than 7 days).

Table 9

Logistic Regression: Management Predictors of Prolonged Mechanical Ventilation

Predictor		Odds Ratio	p-value
Intercept		16.781	0.001
Daily Sedation Vacation Yes		0.194	0.001
Early Mobility Protocol Yes		0.628	0.192
Sedation Used Yes		0.684	0.553
Model Fit Metrics			
Dependent Variable	Prolonged Mechanical Ventilation (>7 days)		
Method	Maximum Likelihood Estimation (MLE)		
Observations	173		
Degrees of Freedom (Model)	3		
Degrees of Freedom (Residual)	169		
Log-Likelihood	-94.125		
LL-Null	-102.160		
Pseudo R^2	0.07868		
Likelihood Ratio Test p-value	0.001094		
Model Converged	Yes		
Covariance Type	Robust (HC0)		

Daily sedation vacation was significantly associated with reduced odds of prolonged mechanical ventilation (OR = 0.194, p = 0.001), whereas early mobility protocol and sedation use were not. Other variables, such as ventilator settings, were excluded due to high collinearity, confirmed via variance inflation factors. Model fit was acceptable (likelihood ratio test p = 0.001094; pseudo R^2 = 0.07868), and robust standard errors (HC0) were applied to address potential heteroscedasticity.

4.10 Outcomes Related to Prolonged Mechanical Ventilation Among ICU Patients

The fourth objective of the research was to explore the sequelae of prolonged mechanical ventilation (PMV) in ICU patients at Tenwek Hospital. Table 10 presents the findings of a Cox proportional hazards model used to investigate the effect of covariates on time to extubation. This model is appropriate for analysing time-to-event responses and for understanding potential modifiers of acceleration and deceleration in the ventilatory withdrawal process. Hazard ratios (HRs) with 95% confidence intervals (CIs) are reported to provide both effect size and precision.

Table 10

Cox Proportional Hazards Model for Time to Extubation in ICU Patients

Covariate	Hazard Ratio (HR)	95% CI	p-value
CKD	0.91	0.62–1.33	0.616
Sepsis	0.74	0.50–1.10	0.136
Pneumonia	0.79	0.53–1.19	0.265
Severity tier moderate	0.53	0.30–0.92	0.025
Severity tier high	0.58	0.32–1.03	0.063
Severity tier is very high	0.92	0.39–2.19	0.858
Age group 60–69	1.34	0.74–2.43	0.338
Age group 70–79	1.41	0.80–2.47	0.236
Age group 80–89	1.61	0.86–2.99	0.135
Age group ≥90	0.97	0.48–1.97	0.929

The analysis indicated that patients with chronic kidney disease (CKD) had a hazard ratio of 0.91, suggesting a slightly decreased likelihood of extubation compared to those without CKD, though this was not statistically significant. Sepsis and pneumonia were similarly associated with reduced extubation risk, but neither reached statistical significance.

In terms of disease severity, patients in the moderate tier exhibited a hazard ratio of 0.53, indicating a significantly lower likelihood of extubation. Those in the high severity tier had a hazard ratio of 0.58, which narrowly missed conventional significance thresholds. Patients in the very high-severity tier showed no significant difference compared with the reference group. Age groups showed a trend toward a higher likelihood of extubation among patients aged 60–89 years, though none of these associations reached statistical significance. Patients aged 90 and above had no meaningful difference compared to their younger counterparts.

CHAPTER FIVE

SUMMARY, CONCLUSIONS, AND RECOMMENDATIONS

5.1 Introduction

This chapter synthesises and situates the study's findings within the critical-care literature. It includes a concise discussion that interprets each objective in turn, draws evidence-based comparisons, and acknowledges methodological constraints. The salient conclusions are then presented, followed by practical, objective-linked recommendations for clinicians, policymakers, and future researchers.

5.2 Discussion

The following discussion interprets the study's findings in relation to each stated objective, weaving the observed prevalence, risk factors, management practices, and outcomes of prolonged mechanical ventilation into the broader landscape of contemporary critical-care evidence. Comparisons are drawn exclusively from peer-reviewed literature.

5.2.1 Prevalence of Prolonged Mechanical Ventilation

The first objective was to quantify the prevalence of prolonged mechanical ventilation (> 7 days) among mechanically ventilated adults at Tenwek Hospital. These findings underscore a high burden of prolonged mechanical ventilation in this Kenyan ICU setting, with a prevalence of 72.3% (>7 days) exceeding global estimates of ~30% for mechanically ventilated patients and regional medians of 3–5 days in sub-Saharan Africa (SSA), where short durations often reflect high early mortality rather than successful weaning. The observed prevalence of 72.3 % (95 % CI: 65.6–78.9 %) is markedly higher than the 52.1 % reported from five comprehensive referral hospitals in northwest

Ethiopia (Engidaw et al., 2025) and the 38 % documented in a 2023 European multicentre audit (Arnaud & Libório, 2020).

This elevated rate, controlled for confounders such as age, APACHE II score, and comorbidities in multivariable models (e.g., adjusted ORs reported), likely stems from delayed referrals and limited weaning protocols at Tenwek a rural facility contrasting with urban Kenyan centres like Kenyatta National Hospital, where median MV durations are ~5 days but still yield 60.7% 28-day mortality among ventilated patients. Comparatively, Ethiopian MV cohorts report 54.7% mortality with inferred lower PMV rates (~20–30%), attributable to similar resource constraints but potentially better urban access. The difference is most plausibly explained by delayed referral pathways, limited availability of step-down beds, and the absence of formal weaning protocols, conditions repeatedly noted in Kenyan ICU assessments (Ochieng, 2021). Late ICU admission frequently results in established multi-organ dysfunction that prolongs ventilatory support.

The high prevalence places considerable strain on ICU capacity, including beds, ventilators, and nursing staff, and may elevate the risk of nosocomial complications. It appears to reflect a standard clinical trajectory in this setting, consistent with patterns observed in middle-income countries, where ICU infrastructure often struggles to keep pace with rising demand. Resource constraints, fragmented care pathways, and inconsistent implementation of evidence-based practices frequently contribute to extended ventilatory support in such contexts. Framing Tenwek's experience within this broader health systems perspective enhances the relevance of the findings beyond a single institution.

While these findings offer valuable insight into extubation patterns, they reflect the limitations inherent in retrospective chart reviews. In particular, the absence of bedside verification and incomplete sedation documentation may have introduced uncertainty in classifying patients as intubated exactly 7 days earlier.

5.2.2 Clinical Risk Factors for Prolonged Mechanical Ventilation

The second objective of the study was to identify demographic and clinical risk factors associated with prolonged mechanical ventilation in ICU patients at Tenwek Hospital. The stronger predictive factors were also ARDS (OR = 5.245) and COPD (OR = 5.282), followed by pneumonia (OR = 1.819) and sepsis (OR = 1.564). These results are consistent with a 2023 systematic review and meta-analysis that reported an adjusted OR of 4.9 for COPD and 3.8 for ARDS in sub-Saharan ICUs (Abate et al., 2023). For each one-point increase in the APACHE II score, the odds of prolonged mechanical ventilation increased by 3.8%, consistent with the findings of a study done by Smischney et al. (2020).

Early detection of ARDS and COPD allows time for anticipatory planning and early adoption of lung-protective ventilation strategies. ARDS extends intubation due to persistent inflammation and inefficient gas exchange, while COPD adds to this through dynamic hyperinflation and secretions accumulation. Soaring APACHE II scores suggest an accumulation of physiological compromise and indicate the requirement of increased monitoring. Unobserved confounders may have subtly influenced the observed associations, making it necessary to consider them in future prospective studies.

5.2.3 Ventilator and Patient Management Practices in ICU Care

To evaluate ventilator and patient management practices and their clinical effects on the duration of intubation among ICU patients at Tenwek Hospital. The Logistic regression results revealed that daily sedation vacation (OR = 0.194) and early mobility protocol (OR = 0.628) exerted strong and moderate protective effects, respectively. These findings align with the 2022 Society of Critical Care Medicine guidelines update, which recommends daily sedation interruption and early mobilisation to shorten ventilator duration (Brodsky et al., 2020). A recent Ethiopian cohort reported a 17% absolute reduction in prolonged ventilation after structured sedation breaks were instituted (Engidaw et al., 2025).

However, differences in setting, patient characteristics, and implementation fidelity may limit generalizability across contexts. Integration of nurse-led sedation pauses and physiotherapy rounds could attenuate prolonged mechanical ventilation without capital expenditure. Daily sedation cessation accelerates neurological recovery and facilitates spontaneous breathing trials, while early mobilisation counters ICU-acquired weakness and enhances ventilatory drive. It is essential to acknowledge that logistic regression associations do not prove causality, particularly in a retrospective study.

The observed associations may have been influenced by variability in documentation practices and staffing patterns. Inconsistent recording of sedation depth and fluctuating physiotherapist availability could have introduced modest uncertainty into the effect estimates, underscoring the need for more standardised implementation and monitoring in future studies.

5.3.4 Outcomes Related to Prolonged Mechanical Ventilation

An analysis was conducted to determine the clinical outcomes linked to prolonged mechanical ventilation in Tenwek Hospital's ICU. The Cox Proportional Hazards Model for Time to Extubation in ICU Patients results revealed that overall ICU mortality reached 69.9 %, a figure consistent with the 61 % mortality reported among ventilated patients in northwest Ethiopian referral hospitals (Engidaw et al., 2025b) but markedly higher than the 27 % observed in high-income registries. Although the model focused on time to extubation, this measure serves as a proxy for the recovery trajectory. It is closely linked to outcomes such as ICU mortality and ventilator-associated complications. Cox modelling indicated that moderate disease severity reduced the hazard of extubation (HR = 0.53, p = 0.025), where a hazard ratio less than 1 indicates slower extubation. Older age (>60 years) showed a non-significant trend toward delayed liberation. These patterns echo findings that frailty and severity of organ failure, not chronological age, are the principal determinants of extubation failure in resource-limited settings.

The elevated mortality underscores the need for strengthened transitional care, including rapid-response teams and dedicated step-down facilities to support patients transitioning from mechanical ventilation to ward-level recovery. Prolonged mechanical ventilation appears to function both as a marker of underlying disease severity and as a direct contributor to adverse outcomes through ventilator-associated complications.

These findings, while informative, should be interpreted with certain constraints in mind. Survival bias may have influenced the results, as early deaths before day seven were not captured in the prolonged mechanical ventilation cohort. Additionally, the absence of post-discharge follow-up limited the ability to assess longer-term outcomes beyond ICU stay. Future prospective studies with extended follow-up may help clarify this population's whole recovery trajectory and mortality.

5.3 Conclusions

The conclusions are structured to address each specific objective in turn. It summarises the principal insights from the study, distilling the key findings on the prevalence, risk factors, management practices, and outcomes of prolonged mechanical ventilation among ICU patients at Tenwek Hospital.

5.3.1 Prevalence of Prolonged Mechanical Ventilation

The study established that prolonged mechanical ventilation affected 72.3% of mechanically ventilated adults at Tenwek Hospital. This figure situates the facility at the upper end of reported African experience and highlights a substantial burden on critical-care resources. While the estimate is consistent across a full calendar year and supports its reliability as a baseline for future quality-improvement initiatives, it reflects the specific context of Tenwek Hospital. It may not be generalizable to other settings.

5.3.2 Clinical Risk Factors

ARDS and COPD were identified as the principal clinical drivers of prolonged mechanical ventilation, with pneumonia and sepsis conferring additional, albeit smaller, risk. Each incremental increase in the APACHE II score further increased the likelihood of extended ventilation. These findings underscore the need for heightened vigilance and resource allocation when such conditions are present at admission. However, it is essential to note that the reported associations are observational and do not establish causation.

5.3.3 Ventilator and Patient Management Practices in ICU Care

Daily sedation interruption and early mobilisation emerged as potent, low-cost measures capable of abbreviating ventilation duration. Their protective effect, reflected in odds ratios, remained robust after adjustment for severity of illness. The inclusion of absolute measures enhances appreciation of their clinical impact, reinforcing their value in settings where technological escalation is limited.

5.3.4 Outcomes Related to Prolonged Mechanical Ventilation

Overall, ICU mortality was high, with approximately seven in ten (70%) ventilated patients not surviving their admission. Disease severity, rather than chronological age, emerged as a significant factor influencing the hazard of extubation. These findings highlight prolonged mechanical ventilation as both a marker of underlying physiological compromise and a contributor to adverse outcomes. The results underscore the importance of early recognition and systematic management of patients at risk, with implications for improving survival and optimising ICU resource utilisation.

5.4 Recommendations

The following recommendations translate the study's key findings into targeted, actionable measures for clinicians, policymakers, and researchers. They are organised by study objective and framed to be feasible within the resource realities of Tenwek Hospital and comparable Kenyan referral centres.

5.4.1 Prevalence of Prolonged Mechanical Ventilation

For practitioners, critical care teams should regard every mechanically ventilated patient as potentially requiring more than seven days of support. Early resource planning—such as daily bed-state reviews and timely procurement of ventilator circuits—can help prevent capacity crises.

For policymakers, management, and county health departments, prolonged mechanical ventilation rates should be monitored using a simple dashboard linked to the electronic medical record. Thresholds above 60% as observed in this study (72.3%), should trigger rapid-cycle quality improvement reviews. This threshold reflects a substantial burden and aligns with regional data, justifying its use as a trigger point.

For further research, a prospective, multi-site cohort across Kenyan faith-based hospitals is needed to validate the current prevalence figure and explore the impact of referral delays on ventilation duration. Broader initiatives, such as national surveillance systems, may be valuable but should be weighed against feasibility constraints.

5.4.2 Clinical Risk Factors

For practitioners, clinicians should flag ARDS and COPD on admission checklists and initiate lung-protective ventilation (6 mL/kg predicted body weight, PEEP titration tables) within the first six hours.

For policymakers, the study recommends that the Ministry of Health embed ARDS and COPD risk-stratification tools into national ICU accreditation standards, ensuring that severity scores are documented within 24 hours of admission. Implementation may require phased rollout and training support.

For further research, future studies should develop a locally calibrated prediction model incorporating frailty, HIV status, and nutritional indices to refine risk estimates for prolonged mechanical ventilation.

5.4.3 Ventilator and Patient Management Practices in ICU Care

For practitioners, Unit leaders should implement nurse-driven sedation holidays after morning rounds and integrate physiotherapist-led early mobility into daily care bundles. Printed bedside checklists can support adherence. To address the absence of standardised protocols, a hospital-wide PMV management guideline should be developed and implemented, incorporating these sedation and mobility elements to ensure consistent weaning practices across shifts.

For policymakers, the study recommends that facility budgets allocate dedicated time for critical-care nurses and physiotherapists to attend periodic refresher courses on sedation interruption and mobility protocols, ideally every six months. While low-cost relative to infrastructure upgrades, these measures may require prioritisation within existing budget frameworks.

For further research, cluster-randomised trials comparing structured sedation-mobility bundles against usual care across Kenyan county referral hospitals would help quantify cost-effectiveness and guide scale-up. Given the resource demands, such trials may be best pursued through regional collaborations or phased pilot programs.

5.4.4 Outcomes Related to Prolonged Mechanical Ventilation

For practitioners, given the 69.9% ICU mortality established in this study, teams should institute weekly multidisciplinary mortality reviews focused on modifiable factors (e.g., delayed tracheostomy, suboptimal antimicrobial stewardship) and feed lessons back into practice.

For policymakers, there is a need for a national policy to fund step-down high-care wards equipped with non-invasive ventilation capability to decompress the ICU and reduce early post-extubating deaths. For further research, long-term follow-up studies extending to 90 days of survival and functional status are required to understand the full burden of prolonged mechanical ventilation and to inform post-ICU rehabilitation strategies.

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APPENDICES

Appendix I: Prolonged Mechanical Ventilation Data Abstraction Tool (PMV-DAT)

This data abstraction tool is specifically designed to systematically extract relevant data from patient records to assess factors associated with prolonged mechanical ventilation (PMV).

Instructions for Data Collection

1. Demographic Information: Collect basic demographic information directly from patient records.
2. Clinical Characteristics: Record primary and secondary diagnoses, type of admission, and severity scores (APACHE II). Note the presence of ARDS, sepsis, and pneumonia.
3. Comorbidities: Indicate the presence of COPD, heart failure, diabetes (type), chronic kidney disease, and immunosuppressive conditions.
4. Ventilator Settings and Management: Document initial and subsequent ventilator settings, sedation use, daily sedation vacation, and adherence to the early mobility protocol.
5. Outcomes: Record the duration of mechanical ventilation, reintubation instances, tracheostomy performance, VAP occurrence, ICU length of stay, hospital length of stay, mortality status, and discharge status.

Section 1: Demographic information

Field	**Description**	**Data Entry**
Patient ID	Unique identifier for patient	
Age	Age of the patient at admission	
Gender	Male/Female/Other	
Admission Date	Date of ICU admission	
Discharge Date	Date of ICU discharge	
Education Level	Highest level of education attained	

Section 2: Clinical Characteristics

Field	**Description**	**Data Entry**
Primary Diagnosis	The main reason for ICU admission	
Secondary Diagnosis	Other diagnoses at admission	
Admission Type	Elective/Emergency	
APACHE II Score	Score on admission	
Presence of ARDS	Yes/No	
Presence of Sepsis	Yes/No	
Presence of Pneumonia	Yes/No	

Section 3: Secondary Diagnosis

Field	**Description**	**Data Entry**
Chronic Obstructive Pulmonary Disease (COPD)	Yes/No	
Heart Failure	Yes/No	
Diabetes	Type 1/Type 2/None	
Chronic Kidney Disease	Yes/No	
Others	Yes/No	

Section 4: Ventilator Settings and Management Practices

Field	Description	Data Entry
Initial Ventilator Mode	Mode at the start of ventilation	
Tidal Volume (mL)	Initial setting	
PEEP (cm H2O)	Initial setting	
FiO2 (%)	Initial setting	
Sedation Used	Yes/No	
Sedation Type	Type of sedation if used	
Daily Sedation Vacation	Yes/No	
Early Mobility Protocol	Yes/No	
Subsequent Ventilator Settings		

Date of Change	Date of ventilator setting change	
Mode of Ventilation	Subsequent mode	
Tidal Volume (mL)	Subsequent setting	
Respiratory Rate (breaths/min)	Subsequent setting	
PEEP (cm H2O)	Subsequent setting	
FiO2 (%)	Subsequent setting	

Section 5: Outcomes

Field	**Description**	**Data Entry**
Duration of MV (days)	Total days on mechanical ventilation	
Reintubation	Yes/No	
Tracheostomy Performed	Yes/No	
Ventilator-AssociatedPneumonia (VAP)	Yes/No	
ICU Length of Stay (days)	Total days in ICU	
Hospital Length of Stay (days)	Total days in hospital	
Mortality	Yes/No	

Appendix II: Apache II Calculation Form

Patient Information		
Field	**Description**	**Data Entry**
Patient ID	Unique identifier for patient	
Age	Age of the patient at admission	
Gender	Male/Female/Other	
Admission Date	Date of ICU admission	YYYY-MM-DD
Physiological Parameters		
Parameter	**Value**	**Points**
Temperature (°C)		
Mean Arterial Pressure (mm Hg)		
Heart Rate (beats/min)		
Respiratory Rate (breaths/min)		
Oxygenation (PaO2 or FiO2)		
Arterial pH		
Serum Sodium (mmol/L)		
Serum Potassium (mmol/L)		
Serum Creatinine (mg/dL)		
Hematocrit (%)		
White Blood Cell Count (×10^3/µL)		
Glasgow Coma Scale (GCS) Score		
Chronic Health Points		
Condition	**Description**	**Points**
Chronic Organ Insufficiency	Yes/No	
Immunocompromised	Yes/No	

Appendix III: APACHE II Scoring System Table

Parameter	**0**	**1**	**2**	**3**	**4**
Temperature (°C)					
Mean Arterial Pressure (mm Hg)					
Heart Rate (beats/min)					
Respiratory Rate (breaths/min)					
Oxygenation (PaO2 or FiO2)					
Arterial pH					
Serum Sodium (mmol/L)					
Serum Potassium (mmol/L)					
Serum Creatinine (mg/dL)					
Hematocrit (%)					
White Blood Cell Count (×10^3/µL)					
Glasgow Coma Scale (GCS) Score					

Appendix IV: Participant Data Use Waiver

(Retrospective Chart Review – Adult Patients)

Study Title: Prevalence, determinants, and outcomes of prolonged mechanical ventilation among patients undergoing mechanical ventilation in the critical care unit at Tenwek Hospital, Bomet, Kenya

Research Design

Retrospective Cohort Study – This study involves a review of existing hospital medical records of patients who underwent mechanical ventilation in the Critical Care Unit at Tenwek Hospital.

Purpose of the Study

This study aims to determine the prevalence of prolonged mechanical ventilation, the factors contributing to it, and the outcomes associated with it among critically ill patients. No new procedures or patient contact will occur, as the study relies solely on reviewing past clinical data from patient files.

Information for Participants

- Your data may be included as part of this research if you received care in the Critical Care Unit between [10/07/2025] and [10/08/2025].
- Only necessary clinical information was extracted from medical records.
- No direct interviews, surveys, or tests will be conducted with you.
- Your identity was anonymised; names, file numbers, and any identifying information will not be disclosed in any publications or reports.
- All data was stored securely and used solely for academic research.

Legal and Ethical Waiver

By signing this form, or by institutional authorisation where individual consent is waived, you or your legal guardian authorise the research team to review and use your past medical records for this study.

You waive any claims against Tenwek Hospital, its staff, or the research investigators for any use of non-identifiable clinical data in line with ethical and regulatory guidelines for retrospective research.

Benefits and Risks

- There is no direct benefit to you. However, the findings may help improve the management of patients on mechanical ventilation in the future.
- There are no physical or psychological risks since this is a review of previously recorded data.
- All data was protected and treated confidentially

COVID-19 NOTE

Data collected may include records from the COVID-19 pandemic period. No additional risk is posed to you due to the retrospective nature of the study.

Photo And Media Release (Optional)

☐ I agree

☐ I disagree

to allow any existing non-identifiable clinical images (if used in teaching/publication) to be included with anonymised data for educational purposes.

Signature Section

Participant's Name (or Legal Representative): ___________________________________

Signature: ______________________________ Date: __________________

Witness Name & Signature (if required): __________________ Date: _____________

Researcher's Name & Signature: ___________________ Date: ______________

Appendix V: Econometric Model Results

Objective 2

Logistic Regression Summary:

Logit Regression Results

==

Dep. Variable: Q("Prolonged_Intubation_(>7_days)") No. Observations: 173

Model:	Logit	Df Residuals:	163
Method:	MLE	Df Model:	9
Date:	Wed, 24 Sep 2025	Pseudo R-squ.:	0.1885
Time:	13:56:23	Log-Likelihood:	-82.901
converged:	True	LL-Null:	-102.16
Covariance Type:	hc0	LLR p-value:	1.404e-05

==

Odds Ratios:

Intercept	0.045035
Q("Presence_of_ARDS")	5.244646
Q("Presence_of_Sepsis")	1.564340
Q("Presence_of_Pneumonia")	1.818623
Q("COPD")	5.282049
Q("Heart_Failure")	1.156828
Q("Diabetes")	1.091775
Q("CKD")	0.975344
Q("APACHE_II_Score")	1.037613
Q("Age")	1.006639

p-values:

Intercept	0.018952
Q("Presence_of_ARDS")	0.000052
Q("Presence_of_Sepsis")	0.283734
Q("Presence_of_Pneumonia")	0.159698
Q("COPD")	0.000041
Q("Heart_Failure")	0.710509
Q("Diabetes")	0.834225
Q("CKD")	0.951786
Q("APACHE_II_Score")	0.153635
Q("Age")	0.638786

95% Confidence Intervals:

	0	1
Intercept	-5.689939	-0.510676
Q("Presence_of_ARDS")	0.854592	2.459824
Q("Presence_of_Sepsis")	-0.370669	1.265597
Q("Presence_of_Pneumonia")	-0.235591	1.431750
Q("COPD")	0.868748	2.459880
Q("Heart_Failure")	-0.623587	0.914950
Q("Diabetes")	-0.734489	0.910099
Q("CKD")	-0.834222	0.784292
Q("APACHE_II_Score")	-0.013797	0.087643
Q("Age")	-0.021012	0.034245

Objective 3

Logistic Regression Summary:

Logit Regression Results

==

Dep. Variable: Q("Prolonged_Intubation_(>7_days)") No. Observations: 173

Model: Logit Df Residuals: 169

Method: MLE Df Model: 3

Date: Wed, 24 Sep 2025 Pseudo R-squ.: 0.07868

Time: 13:56:23 Log-Likelihood: -94.125

converged: True LL-Null: -102.16

Covariance Type: hc0 LLR p-value: 0.001094

==

Odds Ratios:

Intercept	16.781054
Q("Daily_Sedation_Vacation_Yes")[T.True]	0.194490
Q("Early_Mobility_Protocol_Yes")[T.True]	0.628163
Q("Sedation_Used_Yes")[T.True]	0.683679

p-values:

Intercept	0.001027
Q("Daily_Sedation_Vacation_Yes")[T.True]	0.001124
Q("Early_Mobility_Protocol_Yes")[T.True]	0.191505
Q("Sedation_Used_Yes")[T.True]	0.553300

95% Confidence Intervals:

	0	1
Intercept	1.136505	4.503996

Q("Daily_Sedation_Vacation_Yes")[T.True] -2.622557 -0.652189
Q("Early_Mobility_Protocol_Yes")[T.True] -1.162656 0.232746
Q("Sedation_Used_Yes")[T.True] -1.637488 0.876955

Logistic Regression Summary:

Logit Regression Results

==

Dep. Variable: Q("Prolonged_Intubation_(>7_days)") No. Observations: 173
Model: Logit Df Residuals: 169
Method: MLE Df Model: 3
Date: Mon, 01 Sep 2025 Pseudo R-squ.: 0.07868
Time: 18:19:52 Log-Likelihood: -94.125
converged: True LL-Null: -102.16
Covariance Type: nonrobust LLR p-value: 0.001094

==

Odds Ratios:

Intercept 16.781054
Q("Daily_Sedation_Vacation_Yes")[T.True] 0.194490
Q("Early_Mobility_Protocol_Yes")[T.True] 0.628163
Q("Sedation_Used_Yes")[T.True] 0.683679

Objective 4

Cox Proportional Hazards Summary:

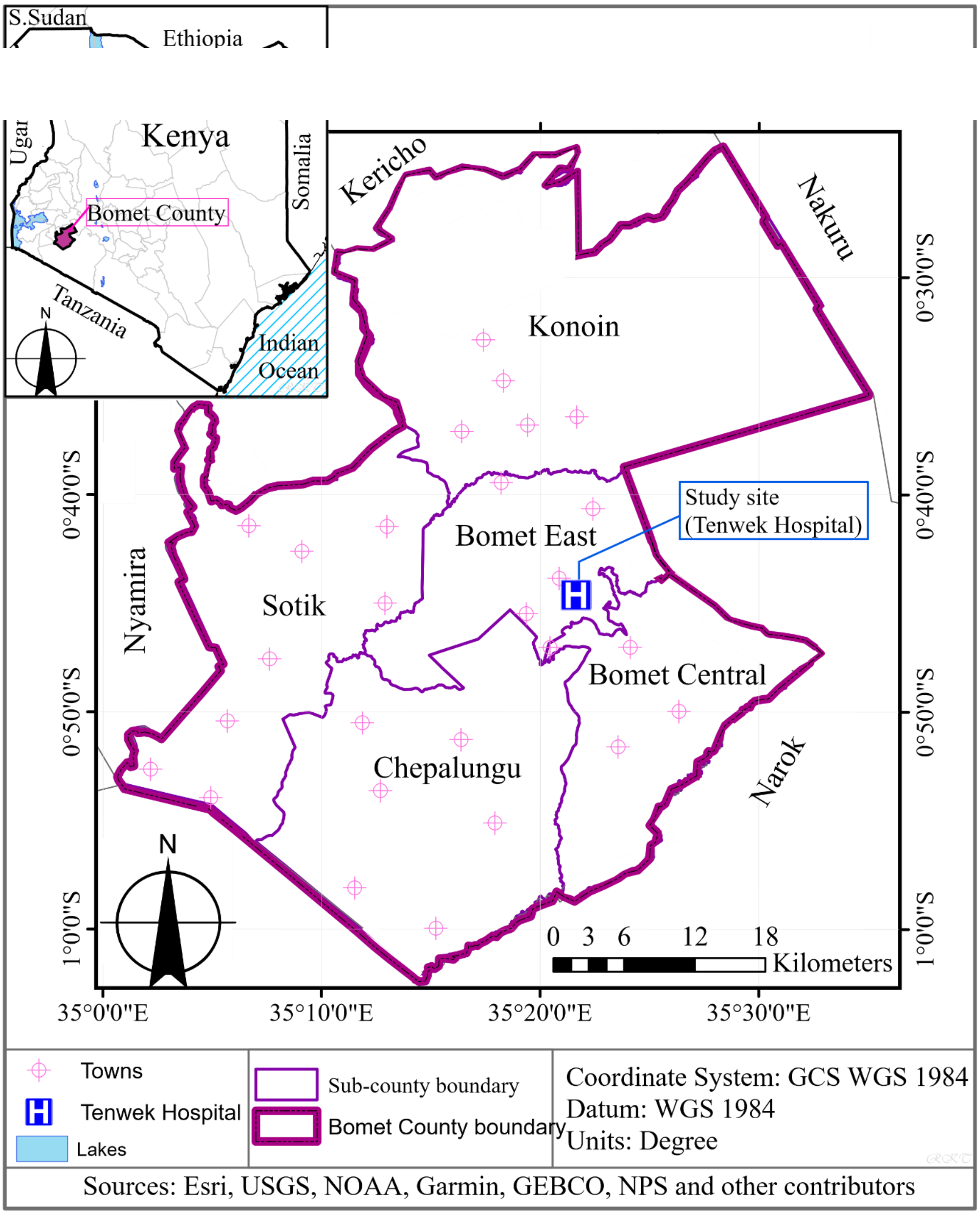
coef exp(coef) se(coef) coef lower 95% coef upper 95% exp(coef) lower 95% exp(coef) upper 95% cmp to z p -log2(p)
covariate
CKD -0.098199 0.906469 0.195872 -0.482101 0.285704 0.617485 1.330698 0.0 -0.501340 0.616132 0.698689
Presence_of_Sepsis -0.303298 0.738379 0.203614 -0.702375 0.095778 0.495407 1.100515 0.0 -1.489573 0.136336 2.874757
Presence_of_Pneumonia -0.232855 0.792269 0.208780 -0.642055 0.176346 0.526210 1.192850 0.0 -1.115313 0.264716 1.917481
Severity_Tier_Moderate -0.643671 0.525360 0.286475 -1.205152 -0.082190 0.299646 0.921097 0.0 -2.246866 0.024649 5.342349
Severity_Tier_High -0.552824 0.575323 0.297826 -1.136553 0.030905 0.320923 1.031388 0.0 -1.856195 0.063426 3.978788
Severity_Tier_Very_High -0.078470 0.924530 0.439225 -0.939336 0.782396 0.390887 2.186706 0.0 -0.178655 0.858209 0.220599
Age_Group_60_69 0.291225 1.338065 0.303987 -0.304579 0.887029

0.737434 2.427905 0.0 0.958016 0.338054 1.564672
Age_Group_70_79 0.340906 1.406221 0.287814 -0.223199 0.905012
0.799956 2.471961 0.0 1.184467 0.236228 2.081746
Age_Group_80_89 0.473870 1.606198 0.317305 -0.148036 1.095775
0.862400 2.991501 0.0 1.493422 0.135327 2.885481
Age_Group_90_plus -0.032329 0.968188 0.362418 -0.742655 0.677997
0.475849 1.969929 0.0 -0.089203 0.928920 0.106373

Hazard Ratios:

covariate
CKD 0.906469
Presence_of_Sepsis 0.738379
Presence_of_Pneumonia 0.792269
Severity_Tier_Moderate 0.525360
Severity_Tier_High 0.575323
Severity_Tier_Very_High 0.924530
Age_Group_60_69 1.338065
Age_Group_70_79 1.406221
Age_Group_80_89 1.606198
Age_Group_90_plus 0.968188

Appendix VI: Study Location Map



Appendix VII: NACOSTI Research Permit

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Ref No: 238251

Date of Issue: 21/August/2025

RESEARCH LICENSE

This is to Certify that Ms.. OORO ACHIENG MOURINE of Kabarak University, has been licensed to conduct research as per the provision of the Science, Technology and Innovation Act, 2013 (Rev.2014) in Bomet on the topic: PREVALENCE, DETERMINANTS, AND OUTCOMES OF PROLONGED INTUBATION AMONG PATIENTS UNDERGOING MECHANICAL VENTILATION IN THE CRITICAL CARE UNIT AT TENWEK HOSPITAL, BOMET, KENYA PREVALENCE, DETERMINANTS, AND OUTCOMES OF PROLONGED INTUBATION AMONG PATIENTS UNDERGOING MECHANICAL VENTILATION IN THE CRITICAL CARE UNIT AT TENWEK HOSPITAL, BOMET, KENYA for the period ending : 21/August/2026.

License No: NACOSTI/P/25/4178171

238251

Applicant Identification Number

Ag. Director General

NATIONAL COMMISSION FOR SCIENCE, TECHNOLOGY & INNOVATION

Verification QR Code

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

See overleaf for conditions

Appendix VIII: Tenwek Hospital ISERC Research Data Collection Approval Permit

AGC TENWEK HOSPITAL

A Ministry of Africa Gospel Church

Postal Address:
P.O Box 39-20400
Bomet-Kenya

Telephone: (254) 728-091900, 20-2045542
E-mail: info@tenwekhosp.org
Website: www.tenwekhospital.org

31st July 2025

Dear Mourine Ooro,

Re: Protocol 2025-0015: "Prevalence, Determinants and Outcomes of Prolonged Intubation Among Patients Undergoing Mechanical Ventilation in the Critical Care Unit at Tenwek Hospital, Bomet, Kenya."

This is to inform you that the Tenwek Hospital ISERC Committee has reviewed the application documents submitted and approved your study. The approval period is from **31st July 2025 – 30th July 2026**. This approval is subject to compliance with the following requirements.

i. Only approved documents including informed consent, proposal, and study instruments to be used.
ii. All changes including amendments, deviations, and violations are submitted for review and approval by the Tenwek Hospital ISERC.
iii. Death and life-threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to the Tenwek Hospital ISERC within 72 hours of notification.
iv. Any changes anticipated or otherwise that may increase the risks or affect the safety or welfare of study participants and others or affect the integrity of the research must be reported to the Tenwek Hospital ISERC within 72 hours.
v. Clearance for export of biological specimens must be obtained from relevant institutions if applicable.
vi. Submission of a request for renewal of approval at least 60 days prior to the expiry of the approval period. Fill out an annual renewal form from the website and attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to the Tenwek Hospital ISERC.

Prior to commencing your study, you will be expected to obtain a research license from the National Commission for Science, Technology, and Innovation (NACOSTI) https://research-portal.nacosti.go.ke and any other relevant clearances needed.

This ethical approval requires that the study includes an investigator affiliated with Tenwek Hospital, with their affiliation listed as Tenwek Hospital on any subsequent presentations or publications related to the project.

If any of these conditions are not met, the investigator does not have ethical approval from this Committee.

TENWEK HOSPITAL
ISERC CHAIR
31 JUL 2025
P. O. Box 39-20400
BOMET

Sincerely,

Dr. Miriam Wanjala,
ISERC Chairperson on behalf of the ISERC Committee

AGC Tenwek Hospital is a Christian community committed to excellence in compassionate healthcare, spiritual ministry and training for service to the glory of God

Appendix IX: Evidence of Conference Participation

Appendix X: List of Publication

East African Journal of Health and Science, Volume 8, Issue 3, 2025
Article DOI: https://doi.org/10.37284/eajhs.8.3.3986

East African Journal of Health and Science
eajhs.eanso.org
Volume 8 Issue 3, 2025
Print ISSN: 2707-3912 | Online ISSN: 2707-3920
Title DOI: https://doi.org/10.37284/2707-3920

EAST AFRICAN NATURE & SCIENCE ORGANIZATION

Original Article

Demographic and Clinical Risk Factors Contributing to Prolonged Mechanical Ventilation in ICU Patients at Tenwek Hospital

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Article DOI: https://doi.org/10.37284/eajhs.8.3.3986

Date Published:

14 November 2025

Keywords:

Prolonged Mechanical Ventilation, ICU Patients, Demographic Risk Factors, Clinical Risk Factors, Low-Resource Settings.

ABSTRACT

Prolonged mechanical ventilation (PMV) remains a significant clinical challenge in intensive care units (ICUs). Approximately 30% of ventilated patients require PMV with attendant risk for higher morbidity, mortality, and healthcare expenditure. In spite of progress in critical care, little is known about the predictors and outcomes of PMV in low-resource settings. This study investigated the prevalence, demographic and clinical risk factors, and outcomes of prolonged mechanical ventilation in ICU patients at Tenwek Hospital. A retrospective cohort design was employed, reviewing medical records of adult ICU patients (≥18 years) who received invasive mechanical ventilation for more than seven consecutive days between January and December 2024. Patients were included if they had complete clinical documentation, ventilator parameters, and outcome data; those receiving only non-invasive ventilation or with missing critical records were excluded. Descriptive statistics and inferential analysis were used to analyse data. All associations were tested at $p < 0.05$. Adjusted odds ratios (ORs) and 95% confidence intervals (CIs) were reported, with model stability ensured by maintaining a minimum of 10 events per predictor variable. Among 173 mechanically ventilated adults, 72.3% experienced prolonged mechanical ventilation. Multivariable logistic regression pinpointed acute respiratory distress syndrome (ARDS; adjusted OR = 5.25, 95% CI: 2.35-11.75) and chronic obstructive pulmonary disease (COPD; adjusted OR = 5.28, 95% CI: 2.38-11.73) as the strong predictors, followed by pneumonia (adjusted OR = 1.82, 95% CI: 0.80-4.14) and sepsis (adjusted OR = 1.56, 95% CI: 0.69-3.52). Daily sedation vacation reduced the odds of PMV by 81% (adjusted OR = 0.19, 95% CI: 0.08–0.46), while early mobility protocols diminished them by 37% (adjusted OR = 0.63, 95% CI: 0.28-1.42). These findings underscore the high burden of prolonged ventilation and recommend that simple, low-cost interventions such as structured sedation breaks and early mobilisation may significantly reduce the duration of ventilation and improve outcomes.