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Original Article

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

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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.

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INTRODUCTION

Endotracheal 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 the administration of particular drugs to an acutely ill patient (Russotto *et al*., 2022). This intervention is frequently used in the ICU settings among those patients experiencing respiratory failure, major surgery, major trauma, neurological impairments, and severe infections (Neto *et al*., 2015). Inadequate oxygenation or ventilation, inability to protect the airway due to decreased consciousness, progressive clinical deterioration, and organ failure are among the primary indications for intubation (Fan *et al*., 2017).

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 dimensions. PMV increases the cost of care, length of stay, complications, including ventilator-associated pneumonia and respiratory muscle weakness and diminished quality of life (Bissett *et al*., 2019; Maes *et al*., 2021). It is considered for the prolonged use of a mechanical ventilator in cases of patients with acute respiratory distress syndrome (ARDS), pneumonia, and COPD, who require prolonged ICU stay and are at risk of side effects (Böhmer *et al*., 2014). Studies suggest that while the provision of critical care has improved, the occurrence of patients being intubated for an extended duration is still regarded as high, which implies that the external factors and ventilator settings should be optimised to reduce the occurrence of complications of intubation (Caparros & Forbes, 2014).

Approximately one-third of patients are admitted to the ICU globally (Berhe *et al*., 2022). As observed by Maes *et al.* (2021), while most of the patients requiring ventilator support use it for a short duration, around 30% remain on ventilation for more than seven days. Although mechanical ventilation can be lifesaving, it has potential side effects and consequences (Huang *et al*., 2021). Invasive MV is, however, an effective care intervention that stabilises patients with respiratory failure (Emeriaud *et al*., 2023). While MV can be lifesaving, its broader implications and clinical complexities can be better understood through the theoretical frameworks (Telias *et al.*, 2022).

In the United States, the number of adults requiring MV is growing, especially for individuals over 65 years, with an expected 80% increase from 2000 to 2026 (Brodsky *et al*., 2018). Moreover, in developed countries, 2–3 million (ICU) patients are invasively MV each year at the costs ranging between 15 and 27 billion dollars

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annually (Amato *et al*., 2015). The care of critically ill patients is becoming increasingly significant in modern healthcare settings (Huang *et al*., 2021). The burden of critical illness in low and middle-income countries (LMICs) is significant and increasing (Lone *et al*., 2025). For example, critical illnesses represent around 20-30% of hospital admissions in these areas (Yaglowski, 2020). 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 (Tobi *et al*., 2024). For instance, the progressive growth of intensive care units in Addis Ababa has not been proportional to the city's population growth and the increasing demand (Yaglowski, 2020). For this reason, patients admitted to the ICU via emergency centres experience a delay, which significantly burdens emergency centre resources. This delayed ICU admission contributes to prolonged hospital stay, increased hospital morbidity, and 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 (Wachira & Mwai, 2021).

A study in rural Kenya found that the predicted survival rates for critically ill patients on MV were poor overall (Parker *et al*., 2019). The study indicated that while various predictive models showed moderate agreement, those developed in similar resource-limited contexts performed best regarding discrimination and calibration. Hospitals in the study had a mortality rate of 61%, which is relatively comparable to 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 side effects and complications such as asynchrony, nosocomial infection, and high cost to the patient (Huang *et al*., 2021). The weakness of the respiratory muscles has been established as one of the most probable outcomes when the patient is exposed to prolonged MV, which can significantly impact the individual's ventilation and consequently the outcomes in the ICU (Bissett *et al*., 2020). These complications increase with increasing time on MV support, and there is nearly a direct correlation between the two (Ali & Abu-Omar, 2020). If a patient needing PMV can be identified early, then ventilation and sedation strategies would be modified, or those patients would be candidates for early tracheostomy (Micallef *et al*., 2020).

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

Lung-protective ventilation techniques using lower tidal volumes and mild PEEP are useful to reduce ventilator-induced lung injury and to increase survival. Liaqat *et al*. (2021) highlight that such approaches decrease the rate of barotrauma, which is of utmost importance for ARDS patients. However, the higher PEEP levels, in addition to helping oxygenation, can lead to accumulation of intra-thoracic pressure, leading 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. 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

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achieve appropriate oxygenation without causing ventilator-associated morbidity.

Hemodynamic instability may also result from inadequate ventilator settings where excessive intrathoracic pressure decreases venous return and diminishes CO (Cheifetz, 2014). Geri *et al.* (2021) emphasise the relationship between MV with venous congestion and renal perfusion, with the importance of hemodynamic monitoring for the prevention of organ failure. Similarly, Schjørring *et al.* (2020) revealed a direct relationship between oxygenation levels controlled by ventilators and ICU mortality, and the latter highlights the importance of arterial oxygen tension monitoring. The introduction of artificial intelligence (AI) within the field of ventilator management promises novel prospects for patient care. Al-Anazi *et al*. (2024) showed that reinforcement learning techniques can adapt the ventilator based on actionable input signals, leading to better patient outcomes and minimising complications. These developments coincide well with the current trend in more precise individualised patient care, especially in the case of patients with complex clinical pictures necessitating individually tailored ventilation.

In Kenya, critical care services have expanded, but ICUs are under-resourced and access to mechanical ventilation is frequently limited by lack of equipment, high patient-to-staff ratios and lack of training. A study by Amos (2022) at the Moi Teaching and Referral Hospital (MTRH) sheds light on respiratory infection and mechanical ventilation prognis. The findings showed that severe respiratory viral infection was frequently associated with a requirement for artificial ventilation, but that outcomes were poor because of delayed diagnosis and infrequent use of non-invasive ventilation, with variable weaning strategies. Additionally, critical care units in low-resource settings experience late referral to ICU, comorbidities such as HIV and malnutrition, and a lack of standardised weaning protocols, which impact PMV outcomes. For example, the unpublished reports and case audits at MTRH and Kenyatta National Hospital expose high levels of ventilator-associated morbidity, including pneumonia and laryngeal damage, consistent with the findings of Martínez-Martínez *et al*. (2021).

Furthermore, Kenya has unique challenges due to a lack of specialised long-term ventilation facilities and a lack of post-ICU rehabilitation, making PMV management difficult. 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). Moreover, the majority of patients being referred from lower-level facilities come in late with a state of severe sepsis, ARDS, or multi-organ failure, leading to increased risks of PMV and poor outcomes. The shortage of specialised interdisciplinary teams, especially respiratory therapists and physiotherapists, is also a challenge to early mobilisation and structured weaning, which is crucial to shortening the duration of PMV (Bissett *et al*., 2020).

While demographic, clinical and management predictors of the duration of intubation have previously been examined, wide gaps remain for multiple other outcomes related to ICU care at Tenwek. In addition, there is scarce data on the incidence of prolonged mechanical ventilation in Kenya since these studies do not usually report its frequency. Moreover, there is a lack of information on the demographic and clinical risk factors that contribute to delayed intubation, which may be quite different from those in high-income countries due to differences in health systems and patient characteristics. The study sought to determine the demographic and clinical risk factors contributing to prolonged mechanical ventilation in ICU patients at Tenwek Hospital.

This study was 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

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complications and outcomes. The Lung Protective Ventilation Theory focuses on how to avoid damage to the lungs in the clinical situation. The VILI Model is the clinical sequel and is based on pathophysiology, and the Biopsychosocial Model puts the preceding into the context of the patient and the environment.

Prevalence of Prolonged 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) (Sterling *et al.*, 2023). Obesity (BMI >25 kg/m²) raised PMV prevalence to around thirty percent in an influenza cohort because of reduced lung compliance (Huang *et al*., 2021). Machine-learning models predicted PMV with an 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 thirty percent, accompanied by a multi-day increase in mean duration when high FiO_2 concentrations (>60%) were required (Al-Anazi *et al*., 2024). In another cardiac-surgery cohort, the prevalence of PMV hovered around the high twenties and was tied to a prolonged neuromuscular blockade time (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) (Sterling *et al*., 2023). 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 elevated, shaped by resource constraints and a heavy infectious-disease burden. An Ethiopian multicentre investigation documented a PMV rate approaching 30%, with around two-fifths of cases occurring in patients whose Glasgow Coma Scale fell below eight (Abate *et al*., 2023). A hypoxaemia survey spanning Kenya, Malawi, and Rwanda reported prevalence in the mid-teens,

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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, 2024). 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, raised prevalence to the high-twenties through 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).

Kenyan data mirror these regional patterns while underscoring local vulnerabilities. A Nairobi ICU audit reported a PMV rate of around twenty percent, with a prevalence nearing one-third among diabetic patients (OR 1.6, 95% CI 1.2-2.1) (Merali, 2021). At Moi Teaching and Referral Hospital, prevalence hovered just above twenty percent, reaching the mid-thirties in trauma cases (OR 2.0, 95% CI 1.4–2.8) (Amos, 2022). Sepsis audits recorded prevalence in the low twenties, rising to thirty percent when hypotension complicated the presentation (Vali *et al*., 2023). Chronic kidney disease pushed prevalence to thirty percent (OR 1.8, 95% CI 1.2–2.6) (Vali *et al*., 2023). Elderly patients exhibited a prevalence of around twenty percent, climbing toward the mid-thirties when hypertension co-existed. A trauma cohort showed prevalence in the low twenties, approaching forty percent in polytrauma scenarios (Merali, 2021). Delayed intubation, constrained by resource scarcity, yielded prevalence in the mid-twenties (Amos, 2022).

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 carried an odds ratio of 1.45 for PMV exceeding fourteen days, while 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 BMI >25 kg m², doubled the odds of PMV in influenza-related ARDS (OR 2.09; 95% CI 1.65-2.64) through reduced lung compliance and protracted 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 one in three cases. Acute illness severity, captured by APACHE II scores above 24, increases PMV odds by 3.8% per 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*., 2017).

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

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in ARDS raises odds threefold (OR 2.8; 95% CI 1.9–4.1) by extending sedation and diaphragmatic weakness (MacIntyre *et al*., 2017). 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 (Sterling *et al*., 2023).

In sub-Saharan Africa (SSA), demographic and clinical hazards are magnified by late presentation, scarce ICU beds, and endemic infections. A multicentre Ethiopian analysis identified Diabetes (AOR 7.4; 95% CI 3.2-17.1) and depressed 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, especially ventilator-associated pneumonia, compound risk through weak infection-control and prolonged device use (Simmons *et al*., 2024). Malnutrition, affecting roughly one-fifth of ICU admissions, impairs respiratory-muscle strength and extends 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 (Parker *et al*., 2019). In Nairobi referral centres, hypoxaemia complicates around 7% of ICU admissions and carries an 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 because of deferred weaning (Amos, 2022). 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 and 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, generating context-sensitive evidence to inform critical-care practice in resource-limited rural settings. The conceptual framework (Figure 1) presents the relationship between demographic and clinical factors and the dependent variable, the outcome of prolonged mechanical ventilation, moderated by the prevalence of prolonged mechanical ventilation.

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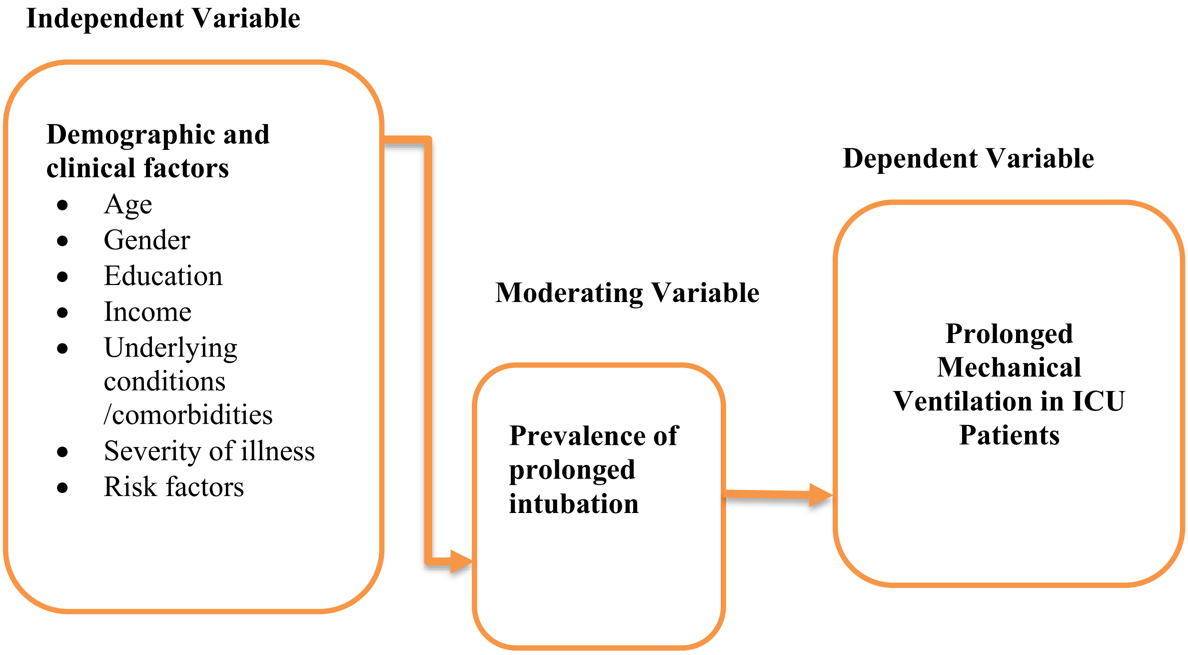
Figure 1: Conceptual Framework



METHODOLOGY

A retrospective cohort design was used to evaluate the prevalence, clinical predictors, and outcomes of prolonged mechanical ventilation among adult patients receiving mechanical ventilation in the critical care unit of Tenwek Hospital, Bomet County, Kenya. Data was extracted from patient records to determine the relationship between patient characteristics, treatment strategies, and clinical outcomes. The population consisted of 173 adult patients admitted to the critical care unit and who required MV support during the study period between January and December in the year 2024. The population consisted of 173 adult patients admitted to the critical care unit who required mechanical ventilation support during the study period between January and December 2024. Inclusion Criteria: (i) age ≥18 years at ICU admission; (ii) receipt of invasive mechanical ventilation via endotracheal intubation or tracheostomy; (iii) mechanical ventilation duration documented in medical records; (iv) complete clinical and demographic data available for analysis. Exclusion Criteria: (i) age <18 years; (ii) receipt of non-invasive ventilation exclusively (e.g., continuous positive airway pressure, bilevel positive airway pressure); (iii) incomplete medical records with missing critical variables such as ventilator parameters, clinical diagnoses, or outcome status; (iv) patients transferred out of the ICU with unknown outcomes; (v) do-not-resuscitate orders limiting full documentation of ventilatory support.

Data were abstracted using a structured data abstraction tool (PMV-DAT) designed to capture key domains, including ventilatory parameters (e.g., tidal volume, PEEP, FiO_2), patient-ventilator interactions, and clinical status, supplemented by pertinent laboratory and imaging findings from medical records. Variables were selected based on the conceptual framework (Figure 1), prioritising demographic factors (e.g., age, sex), clinical risk factors (e.g., ARDS, COPD, APACHE II score), and management strategies (e.g., daily sedation vacations, early mobility protocols) informed by the Lung Protective Ventilation Theory, the Pathophysiological Model of Ventilator-Induced Lung Injury (VILI), and the Biopsychosocial Model. Missing data were minimal (<3%, n=5 cases across variables) and handled via listwise deletion to maintain model integrity without introducing bias. However, as a retrospective study, it is subject to inherent limitations such as incomplete documentation, potential

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misclassification of diagnoses, and inability to control for unmeasured confounders. The sample size of 173 was justified to achieve 80% statistical power (α=0.05) for detecting adjusted odds ratios (ORs) >2 in multivariable models, adhering to the minimum 10 events per predictor variable rule for stability.

Potential confounding variables were identified a priori based on the conceptual framework and literature. These included age, severity of illness (APACHE II score), comorbidity burden (diabetes, hypertension, chronic kidney disease), and management factors (sedation strategies, weaning protocols, staffing ratios). Confounding was addressed through multivariable logistic regression with adjustment for these variables. Interaction terms were assessed but not included in the final model due to insufficient sample size and lack of statistical significance ($p>0.05$).

Data were collected using purpose-designed instruments, including structured data collection sheets, and analysed through multivariable logistic regression to estimate adjusted odds ratios (OR). Statistical associations were tested at a significance threshold of $p < 0.05$, with model robustness verified using robust standard errors and multicollinearity checks (variance inflation factor <5).

RESULTS

Age Distribution of ICU Respondents

Table 1 presents the age distribution of ICU patients at Tenwek Hospital.

Table 1: 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**

Source: *Field data (2025)*

In Table 1, 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.

Prevalence of Clinical Conditions

The prevalence of comorbidities and clinical conditions for the ICU patients was evaluated as presented in Table 2.

Table 2: 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

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	Condition	Frequency	Percent
	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

Source: *Field data (2025)*

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%).

Mortality and Survival Outcomes

Table 3 presents the outcomes for 173 ICU patients at the study setting

Table 3: Patient Outcomes: Mortality and Survival Rates

	Frequency	Percent
Mortality	121	69.9
Survival	52	30.1
Total	**173**	**100.0**

Source: *Field data (2025)*

The majority experienced mortality (n = 121; 69.9%), while the minority survived (n = 52; 30.1%).

Patient Age, APACHE II Score, and Ventilator Settings

Table 4 presents descriptive data for 173 ICU patients at Tenwek Hospital.

Table 4: Summary of Descriptive data for ICU Patient Cohort (n = 173)

Statistic	Age	APACHE II Score	Tidal Volume (mL)	PEEP (cm H_2O)	FiO_2 (%)	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

Source: *Field data (2025)*

Table 4 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, their mean, standard deviation, minimum, maximum, and the interquartile range (25^{th} percentile, 50^{th} percentile, and 75^{th} percentile) are reported. These values present a

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detailed description of the clinical and management features of the cohort.

Tests for Normality

Before undertaking parametric analysis distributional characteristics of continuous variables using the Shapiro-Wilk test was assessed, as presented in Table 5 for the 173 ICU patients.

Table 5: Shapiro-Wilk Test for Normality of Continuous Variables (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 length of stay (days)	0.993	0.524	Normally distributed ($p \geq 0.05$)

Source*: Field data (2025)*

Prevalence of Prolonged Mechanical Ventilation

The prevalence of prolonged mechanical ventilation among Tenwek Hospital ICU patients was examined, as presented in Figure 2. The bar chart illustrates the proportion of patients who experienced PMV lasting more than seven days. This graphical depiction shows that PMV is a common occurrence within the ICU setting.

Figure 2: Prevalence of Prolonged Mechanical Ventilation (>7 days) in ICU Patients

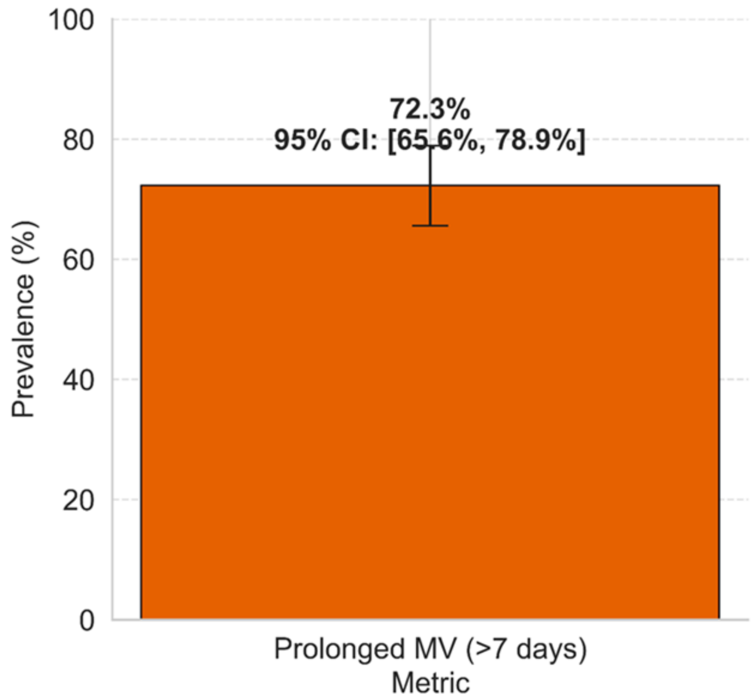

Figure 2 shows that 72.3% of ICU participants had PMV. This percentage is indicated on the graph by the six-error bar, which represents the 95% confidence interval (65.6-78.9%).

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

Demographic and clinical risk factors associated with prolonged mechanical ventilation among ICU patients at Tenwek Hospital are presented in Table 6 with the logistic regression results for clinical predictors. Odds ratios obtained by maximum likelihood estimation approximate the strength of the relationship of each risk factor with prolonged mechanical ventilation.

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Table 6: Logistic Regression: Clinical Predictors of Prolonged Mechanical Ventilation

Predictor	Odds Ratio	p-value
Intercept	0.05	0.02
Presence of ARDS	5.25	0.00
Presence of Sepsis	1.56	0.28
Presence of Pneumonia	1.82	0.16
COPD	5.28	0.00
Heart Failure	1.16	0.71
Diabetes	1.09	0.83
CKD	0.98	0.95
APACHE II Score	1.04	0.15
Age	1.01	0.64
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-value	1.404×10^{-5}	
Model Converged	Yes	
Covariance Type	Robust (HC0)	

Source: *Field data (2025)*

Logistic regression identified ARDS (p-value) and COPD (p-value) as significant predictors of prolonged mechanical ventilation, each associated with markedly increased odds. Other variables, including pneumonia, sepsis, APACHE II score, age, heart failure, diabetes and CKD were not significant, which may reflect limited direct effect on ventilatory duration or the influence of confounding factors such as age and comorbidity burden. While CKD is clinically relevant, its effect may be more indirect or context-dependent, and thus, it is not strongly predictive of prolonged mechanical ventilation in this sample. The model demonstrated good fit (pseudo-$R^2 = 0.1885$; $p < 0.001$) and used robust standard errors to enhance reliability.

DISCUSSION

The high burden of prolonged mechanical ventilation in the Kenyan ICU settings, with a prevalence of 72.3% (>7 days) exceeding global estimates of approximately 30% for mechanically ventilated patients and regional medians of 3–5 days in sub-Saharan Africa (SSA), is notable, as 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 38.3% documented in a 2024 German tertiary care analysis (Trudzinski *et al*., 2024). 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 unstandardized weaning protocols at Tenwek Hospital, being a rural facility (include late referrals) contrasting with urban Kenyan hospitals like Kenyatta National Hospital, where median MV durations are approximately 5 days but still yield 60.7% for 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 that have

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been 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 (Aiesh *et al*., 2023). It appears to reflect a common 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 often contribute to prolonged ventilatory support in these contexts (Priya *et al*., 2024). 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 some uncertainty in classifying patients as having been intubated exactly 7 days prior.

CONCLUSION

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 the year and supports its reliability as a baseline for future quality-improvement initiatives, it reflects the specific context of Tenwek Hospital and may not be generalisable to other settings. Late referral with complications contributes to the prevalence.

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 rise in APACHE II score further amplified 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 important to note that the reported associations are observational and do not establish causation.

RECOMMENDATIONS

For practitioners, critical care teams must approach every mechanically ventilated patient with the expectation that support may extend beyond seven days. Proactive resource planning, such as conducting daily bed-state reviews and ensuring timely procurement of ventilator circuits, can mitigate the risk of capacity crises. Additionally, clinicians should consistently flag Acute Respiratory Distress Syndrome (ARDS) and Chronic Obstructive Pulmonary Disease (COPD) on admission checklists, initiating lung-protective ventilation strategies (6 mL/kg predicted body weight, PEEP titration tables) within the first six hours to optimise outcomes. Include standardisation of weaning protocols.

For policymakers, county health departments and hospital management should routinely monitor prolonged mechanical ventilation rates using a streamlined dashboard integrated with the electronic medical record system. When thresholds exceed 60%, as observed in this study (72.3%), they should trigger rapid-cycle quality improvement reviews. This benchmark reflects a significant clinical burden and aligns with regional data, making it a justified trigger point. Furthermore, the Ministry of Health is encouraged to embed ARDS and COPD risk-stratification tools into national ICU accreditation standards, mandating severity-scored documentation within 24 hours of admission. A phased implementation strategy, coupled with targeted training, may be necessary to ensure effective uptake.

For future research, a prospective, multi-site cohort study across Kenyan faith-based hospitals is warranted to validate the current prevalence figures and investigate the influence of referral delays on ventilation duration. While broader initiatives such as national surveillance systems may offer valuable insights, their feasibility must be critically assessed. Moreover, there is a need to

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develop a locally calibrated prediction model that incorporates frailty, HIV status, and nutritional indices to enhance risk estimation for prolonged mechanical ventilation.

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