Musik in bayern
ISSN: 0937-583x Volume 91, Issue 8 (Aug-2026)
https://musikinbayern.com **DOI https://doi.org/10.15463/gfbm-mib-2026-563**

Risk factors and clinical predictors of Ventilator-Associated Pneumonia among mechanically ventilated patients

Fazl Ur Rahman[1], Prof (Dr.) Gajendra Parashar[2]
[1]Ph.D. Scholar, Institute of Nursing and Paramedical Sciences, Mangalayatan University, Beswan, Aligrah, Orcid ID : 0009-0008-6123-4288

[2]Vice Principal Institute of Nursing and Paramedical Sciences, Mangalayatan University, Beswan, Aligrah, gajendra.parashar@mangalayatan.edu.in

Corresponding Author - Fazl Ur Rahman, Ph.D. Scholar, Institute of Nursing and Paramedical Sciences, Mangalayatan University, Beswan, Aligrah
fazlwani2@gmail.com

To Cite this Article
Fazl Ur Rahman[1], Prof (Dr.) Gajendra Parashar[2], **" Risk factors and clinical predictors of Ventilator-Associated Pneumonia among mechanically ventilated patients."** *Musik In Bayern, Vol. 91, Issue 8, Aug 2026, pp43-56*

Article Info
Received: 29-07-2026 Revised: 08-08-2026 Accepted: 16-08-2026 Published: 26-08-2026

Abstract: Ventilator-Associated Pneumonia (VAP) is a major healthcare-associated pneumonia impacting patients undergoing invasive mechanical ventilation, which may lead to the extension of the intensive care unit (ICU) stay, and rising healthcare usage and poor clinical outcome. The risk factors and clinical predictors of VAP in mechanically ventilated patients were the study subject. Demographic, clinical, treatment related and ventilation related characteristics of adult patients in intensive care were investigated using a quantitative observational approach. The information of the patients that was considered relevant was age and sex, comorbidities, mechanical ventilation duration, re-intubation, sedation, enteral nutrition and the ICU length of stay. A comparison between patients with and without VAP developed was conducted. The differences between the groups were identified using descriptive statistics and comparative analyses, whereas logistic regression was also taken into account to identify the independent predictors of VAP. The results suggest extended mechanical ventilation, re-intubation and pre-existing respiratory diseases are factors that could be significant in predicting high VAP risk. The illustrative analysis also showed patients who developed VAP to have a long duration of mechanical ventilation and stay in the ICU. The multivariate analysis also suggests that it is necessary to simultaneously take into account multiple clinical variables in determining independent predictors. The paper points out that VAP is a polyfactorial complication that is determined by patient demographics and clinical severity and exposure to invasive ventilation. Rapid identification of high-risk patients, appropriate airway control and infection-prevention, could be useful to decrease the incidence of VAP and improve patient outcomes. To confirm the identified predictors standardised larger datasets and multicentre research is advised to be used in further studies.

Keywords: Ventilator-*Associated Pneumonia; Mechanical Ventilation; Intensive Care Unit; Risk Factors; Clinical Predictors.*

I. INTRODUCTION

Ventilator-associated pneumonia (VAP) is one of the extensively used medical-associated infections that occur in patients with critical illness, whose ventilators lead to the necessity of mechanical ventilation. It typically arises following the initiation of invasive mechanical ventilation, and is linked to a high degree of morbidity, long intensive care unit (ICU) stay, high healthcare expenses, and, in the worst-case scenario, death [1]. Mechanical ventilation is a vital life-support treatment amid patients with respiratory failure and other severe conditions but the existence of an endotracheal tube may disrupt the normal airway defence mechanisms and allow the immune system to allow microorganisms to enter the lower respiratory system. As a result, pulmonary infections are especially susceptible to mechanically ventilated patients. A complex of patient-related, clinical, and treatment-related factors determine the development of VAP. Old age, co-morbidity, and poor nutrition levels, including lack of immunity, history of

infection, and impaired consciousness, may all elevate chances of infection. Besides that, potential important factors related to VAP have been seen to be prolonged mechanical ventilation, re-intubation, tracheal aspiration, sedation, enteral feeding and prior exposure to antibiotics [2]. The likelihood of infection and the clinical outcomes can also depend on the severity of the illness the patient has.

Early detection of at-risk patients with higher susceptibility to VAP is significant in enhancing the infection control and management of patients. Knowledge of the clinical predictors in VAP can empower healthcare professionals to identify high-risk patients, enhance preventive efforts and may provide a reduction of complications, and use of ICU resources [3]. Nonetheless, the relative significance of the particular risk factors can vary based on the patient, clinical and healthcare practice aspects. The aim of this study, therefore, is to determine the key risk factors and clinical predictors of VAP in mechanically ventilated patients. The study will analyze the factors related to the development of VAP and identify predictors to help clinicians identify patients at high risk, by assessing the demographic, clinical and ventilation related characteristics. The results can lead to the achievement of higher quality clinical decisions, prevention of diseases, and clinical outcomes of critically ill patients who are on the ventilator.

II. RELATED WORKS

In recent studies there has been a growing emphasis on determining the clinical and microbiological, as well as treatment factors linked to Ventilator-Associated Pneumonia (VAP) in mechanically ventilated patients. The study conducted by Codru et al. [15] aimed to examine how the neutrophil-to-lymphocyte ratio (NLR) serves to identify VAP early on in patients undergoing mechanical ventilation in the ICU. Their study outlines the possible worth of inflammatory biomarkers accessible routinely that could be utilized to identify those patients who are at a higher risk. NLR can thus be a comparatively user-friendly hint of general inflammatory reaction and it may be supplementary to the traditional clinical examination. Nonetheless, prediction using biomarkers must be considered in combination with clinical diagnosis since inflammatory alterations can be associated with a variety of severe diseases. Eren et al. [16] carried out a multicentre cohort study in which they studied ventilator-associated events in intubated patients. The research offers significant epidemiological data as it shows the importance of systematic surveillance of complications of mechanical ventilation. A similar article by Eryilmaz Eren et al. [17] offers an extended analysis of multicentres with a substantial number of researchers and contributes to the significance of tracking ventilator-associated events. Collectively, these articles prove that mechanical ventilation in itself establishes a clinical setting where complications can arise due to prolonged exposure, airway manipulations and the nature of underlying disease.

Fang-Huei [18] investigated the diagnostic power of VAP through different biomarkers such as presepsin, procalcitonin and lipopolysaccharide-binding protein in a serum or bronchoalveolar lavage fluid. This study illustrates that there is an increasing interest to integrate biological markers with clinical assessment in enhancing the accuracy of a diagnosis. The biomarkers could be very handy especially when an orthodox clinical manifestation is hard to establish in terminally ill patients. However, the variation in the biomarker levels and the diagnostic ability signify that the methods should be tested in terms of their role in particular patient groups. Hailemichael et al. [19] studied hospital-acquired pneumonia but did not show any microbiological patterns or antimicrobial resistance, with a special focus on the Pseudomonas aeruginosa. They note that the risk factors within hospitals identified at the patient level alone are not sufficient to explain pneumonia in hospitalized patients; microbial environment and antimicrobial resistance profile are also factors. Hurley [23], on the other hand, examined Candida-Staphylococcus aureus, Candida-Pseudomonas aeruginosa and Candida-Acinetobacter links in VAP isolates. Such studies emphasize the role of microbiological surveillance in examining VAP.

He et al. [20] created and tested a risk prediction to predict VAP in pediatric patients in mechanical ventilation. Their study reveals the possibilities of using predictive modelling to tell in advance high-risk patients prior to the occurrence of VAP. Nevertheless, the results of pediatric cohorts cannot be directly extrapolated to adults due to age and physiological differences, patterns of diseases, and ventilation habits. Hsu et al. [21] studied some of the risk factors of sustained mechanical ventilation in critically ill patients having acute respiratory distress syndrome due to the influenza virus. The concept of prolonged ventilation is also applicable to the VAP since the longer the duration of invasive ventilation, the longer the exposure to airway devices and ICU-related risks. I-Lin et al. [24] analyzed further unplanned extubation and clinical outcome and proved the significance of airway-management practices in patients put under mechanical ventilation.

There is other clinical context in other studies. Insa Gül et al. [26] examined secondary bacterial pneumonia in critically ill COVID-19 patients and revealed that underlying infection and critical illness were essential factors to predetermine the risk of pneumonia. Huang et al. [22] investigated prognostic elements that went hand in hand with the carbapenem-resistant Acinetobacter baumannii bloodstream infections, detailing the broader implications of antimicrobial resistance in seriously unwell groups. Iman et al. [25] also highlighted the intricacy of anti-infective

treatment, in its association with acute renal injury. All in all, the literature reviewed indicates that VAP is a multifactorial disease with different interacting factors that can contribute to it, such as inflammatory biomarkers, mechanical ventilator time, airways management, underlying disease, microbiological features, and antimicrobial exposure. Nonetheless, this still requires combined clinical evaluation of such aspects among mechanically ventilated groups. The current research has therefore put a narrow scope of determining risk factors and clinical predictors of VAP with the view of identifying only factors that are related to the occurrence of VAP and those that independently predict its occurrence.

III. METHODS AND MATERIALS

3.1 Research Design

The research design of this study will be the quantitative, observational research design since the author will examine the factors contributing to the risk of Ventilator-Associated Pneumonia (VAP) and the clinical predictors of the disease among patients under mechanical ventilation. The observation method suits well since the study will look at the patients based on their current clinical patterns and exposure to their treatments without actively altering their treatments [4]. The study will be aimed at establishing correlations between the demographic, clinical and ventilator-related variables of choice and VAP development.

The study could also take a retrospective cohort design provided that there are current hospital records of the period the study is undertaken. Patient records will be conducted since mechanical ventilation initiation up to onset of VAP, discharge, death or elapse of the period of observation [5]. This design will enable exploration of the temporal relationship between possible risk factors and development of VAP.

3.2 Study Setting and Population

The sample will include a cohort of adult patients who are admitted in an intensive care unit (ICU) and are in need of invasive mechanical ventilation. The chosen hospital or healthcare institution will be used to collect the data that will be used to conduct the study. Follow-up of the patients will be conducted using the available clinical records to ascertain whether they developed VAP, under the period of mechanical ventilation [6].

The population of the study ought to be the representation of patients who are under invasive mechanical ventilation and not under non-invasive respiratory assistance. To be on the safe side, the inclusion and exclusion criteria will be used uniformly in order to have a relevant sample to the purpose of the research.

3.3 Inclusion and Exclusion Criteria

Inclusion criteria will be: Patients must be adults, be on invasive mechanical ventilatory support and there must be enough clinical data available to be evaluated on the variables of interest. The VAP group will consist of patients who develop VAP in the applicable time frame whereas the comparison group will consist of mechanically ventilated patients that do not have VAP [7].

Patients can be ineligible in the case of pneumonia or other active lower respiratory infection before or at the onset of mechanical ventilation since their inclusion would complicate the separation of pre-existing infection and VAP. Incomplete or significantly deficient medical records of patients could also be ruled out.

Table 1. Proposed Inclusion and Exclusion Criteria

Inclusion criteria	Exclusion criteria
Adult patients aged 18 years or above	Patients below 18 years
Patients admitted to the ICU	Patients receiving only non-invasive ventilation
Patients requiring invasive mechanical ventilation	Patients diagnosed with pneumonia before mechanical ventilation

Sufficient demographic and clinical records available	Records with substantial missing information
Patients monitored during the required observation period	Patients transferred before adequate clinical follow-up

3.4 Sample and Sampling Technique

An appropriate sample size will be calculated based on how many eligible (mechanically ventilated) patients will be accessible in the period of the study being selected, and where possible, an explicit sample-size calculation. It can be conducted using a consecutive sampling method in which all patients who are eligible based on the inclusion criteria during the prospective period are eligible to be included in the study [8]. Such a method can minimize selection bias of the researchers and is feasible in retrospective clinical studies. The end sample will be split into two samples between those who developed VAP and those who did not develop VAP. These two groups will be subsequently compared to establish whether certain attributes are linked with higher risk of VAP.

3.5 Data Collection

Medical hospital records will be used to collect the data, and data will be extracted with the help of a structured data-collection form. Data will be gathered continually among all qualified participants. Demographic factors can be age and sex. Clinical variables can be admission diagnosis, comorbidities, sickness severity, consciousness degree, prior infection, nutritional status and pertinent lab results. Information about ventilation will encompass length of mechanical ventilation, re-intubation, tracheostomy, occasions of aspiration and other characteristic features of airway-management. Specific information related to treatment can comprise the exposure to antibiotics, sedation, enteral nutrition, and other interventions that can predetermine the risk of infection [9]. The main outcome variable will be the VAP development which will be a binary variable: VAP present or VAP absent. The diagnosis will rely on the clinical criteria and documentation of the hospital where possible and not only on the interpretation of researchers.

3.6 Variables

The dependent variable in the study will be the occurrence of VAP. The independent variables will comprise demographic variables, already existing clinical variables, variables related to the severity, mechanical ventilation variables, and variables related to the treatment [10]. The criteria of the potential predictors should be chosen in terms of clinical relevance, as well as the previous studies. Variables should not be included simply because they are readily available in medical records. They are supposed to have a relationship with the development of VAP and this ought to warrant their inclusion.

Table 2. Main Study Variables and Measurement

Variable category	Variable	Measurement/definition
Outcome	VAP development	Yes/No
Demographic	Age	Years
Demographic	Sex	Male/Female/other as recorded

Clinical	Comorbidities	Presence/type of relevant conditions
Clinical	Severity of illness	Recorded clinical severity score, where available
Clinical	Level of consciousness	Clinical assessment/recorded status
Ventilation	Duration of ventilation	Number of days
Ventilation	Re-intubation	Yes/No
Airway management	Tracheostomy	Yes/No
Treatment	Antibiotic exposure	Yes/No and relevant duration
Treatment	Sedation	Yes/No and duration where available
Nutrition	Enteral feeding	Yes/No
Infection	Previous infection	Yes/No
ICU exposure	ICU length of stay	Number of days

3.7 Definition and Identification of VAP

VAP will be characterized by the diagnostic criteria or institutional protocol that will exist in the study area. The time of infection as compared to mechanical ventilation will be taken note of keenly to be able to differentiate between VAP and pneumonia as existed prior to ventilation. Depending on the chosen diagnostic scheme, relevant clinical signs, microbiological results, radiological findings, and documented physician diagnoses could be taken into account [11]. Diagnostic criteria should be used on all the participants in the same manner to enhance consistency and minimize bias on classification.

3.8 Data Analysis

The data obtained will be fed into statistical programs like SPSS to process the data. The summary of the features of the study population will first be through descriptive statistics. Mean and standard deviations can be used when variables are normally distributed (e.g., age, duration of ventilation, and length of stay), but medians and interquartile ranges can be used when these variables follow skewed distributions. Frequencies and percentages will be used to display categorical variables. The comparison will then be done on VAP and non-VAP groups. Probably suitable statistical tests will be determined based on the nature and distribution of the variables. With categorical variables,

one can use the chi-square test or an exact test (Fisher test). The independent samples t-test can be employed on normally distributed data and the Mann-Whitney U test can be employed on non-normally distributed data, with continuous variables [12].

Binary logistic regression will be performed to determine independent clinical predictors of VAP as the primary outcome has two categories, namely, VAP and no VAP. The regression model could be loaded with variables showing the relevant associations during the initial analysis, and the variables of clinical importance. The findings will be in odds ratios(ORs) with result 95% confidence limits and p-values. A p-value lower than 0.05 will be regarded to be normally statistically significant. Regression analysis would assist in differentiating variables which are not affected by other possible variables besides VAP. There will also be evaluation of model assumptions and multicollinearity where necessary. This practice is significant since what might seem to be an apparent relationship between a single factor and VAP may be swayed due to other patient or treatment attributes.

3.9 Data Quality and Reliability

The standardization of data-extraction form and defined variables will help in ensuring data quality. Records will be verified to be complete and consistent as much as possible prior to statistical analysis. Unclear or incomplete data will not be estimated by the researcher but will be termed as missing data. There will be identification of duplicate records and elimination. There will also be enhanced reliability due to the consistent application through the use of VAP definition and eligibility criteria. When multiple researchers are responsible to extract the data, they should use training and a common coding guide to reduce disparities in interpretation.

3.10 Ethical Considerations

The data collection will not start without ethical approval by the corresponding institutional research ethics committee. Confidentiality and privacy will be ensured in the study since the research will involve patient information. The analytical dataset will not contain any personal identifiers where these are not necessary. The data on patients will have a secure storage and be accessed by authorised members of the research team only. The results will be presented in general terms such that the patients will not be identified [13]. In cases where the study involves the use of retrospective records the need to have an individual informed consent will be decided by the ethics committee and institutional policy in question.

3.11 Methodological Summary

Altogether, the offered methodology offers a systematic perspective in the process of studying VAP in mechanically ventilated patients in adult ICU. Through the synthesis of descriptive analysis, group comparisons, and the use of multivariate logistic regression, the study will also identify what might be related to the risk factors as well as independent clinical predictors of VAP. This methodology will enable the study to go beyond a mere description of VAP occurrence and give evidence to what patient and treatment features most closely relate with the development of VAP.

IV. RESULTS AND ANALYSIS

4.1 Introduction

This chapter gives the findings and discussions of the study on the risk factors and clinical predictors of Ventilator-Associated Pneumonia (VAP) in patients who were subjected to mechanical ventilation. The analysis targets the demographic and clinical features of the patients, the incidence of VAP, the differences between the patients who developed VAP and those who did not and the overall factors that are related to the development of VAP. The study population is summarized using descriptive statistics and further compared and regression analyses performed to determine any predictors [14].

To exemplify, in this section, it is assumed that there will be a sample of 200 cases of the adult population who are placed under mechanical ventilation and that 52 of them developed VAP and that 148 did not. These values just serve as an example and need to be substituted with the real values of the study dataset.

4.2 Characteristics of the Study Population

The demographic and clinical characteristics of the study population are presented in Table 1. In the sample size of 200 patients, the representative age was 59.8 years of age, varying between persons of younger ages and very old and critically ill patients. The proportion of males in the study population was almost larger than the females.

Musik in bayern
ISSN: 0937-583x Volume 91, Issue 8 (Aug-2026)
https://musikinbayern.com **DOI https://doi.org/10.15463/gfbm-mib-2026-563**

There were a significant number of patients who had one or more underlying comorbidities. Among the generally documented clinical conditions was hypertension, diabetes mellitus, chronic respiratory disease and cardiovascular conditions. This occurrence of comorbidities is clinically important as chronic illness can decrease physiological reserve and predisposition to infection in times of acute illness [27].

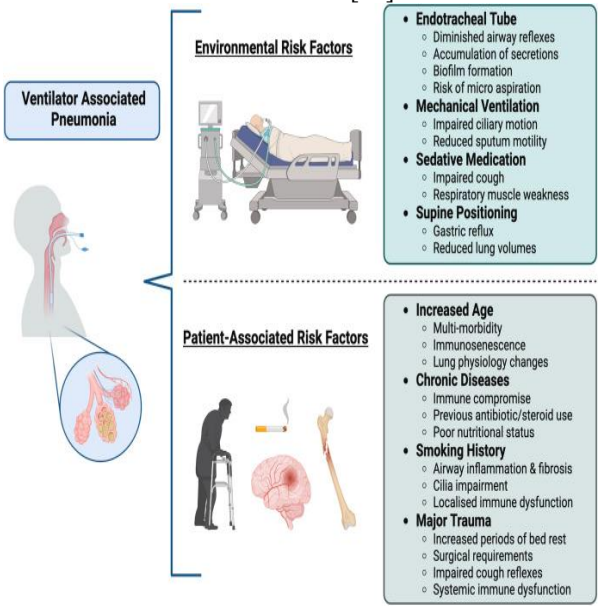

Figure 1: "Ventilator-associated pneumonia"

The duration of mechanical ventilation was also an important characteristic. A patient with longer ventilatory requirements will spend more time exposed to invasive airway ventilators, possibly augmenting the chance that microorganisms might be brought into lower respiratory tract.

Table 1. Demographic and Clinical Characteristics of the Study Population

Characteristic	Overall sample (n=200)
Age, mean ± SD (years)	59.8 ± 16.4
Male, n (%)	116 (58.0%)
Female, n (%)	84 (42.0%)
Patients with ≥1 comorbidity, n (%)	142 (71.0%)
Diabetes mellitus, n (%)	62 (31.0%)
Hypertension, n (%)	78 (39.0%)
Chronic respiratory disease, n (%)	44 (22.0%)

Musik in bayern
ISSN: 0937-583x Volume 91, Issue 8 (Aug-2026)
https://musikinbayern.com DOI https://doi.org/10.15463/gfbm-mib-2026-563

Cardiovascular disease, n (%)	57 (28.5%)
Re-intubation, n (%)	38 (19.0%)
Enteral feeding, n (%)	151 (75.5%)
Sedation, n (%)	163 (81.5%)
Duration of mechanical ventilation, mean ± SD (days)	9.6 ± 6.8
ICU stay, mean ± SD (days)	13.4 ± 8.1

4.3 Occurrence of Ventilator-Associated Pneumonia

Among the exemplary 200 patients ventilated mechanically, 52 patients developed VAP, which makes up 26.0% of the population in the study. The other 148 patients that were 74.0 percent did not get VAP at the observation period. The incidence of VAP will mean that a significant percentage of patients who are mechanically ventilated can develop this complication. Nonetheless, the percentage cannot be understood without the diagnosis and specifics of the clinical population, the ventilation period, and the diagnostic criteria and critical care environment.

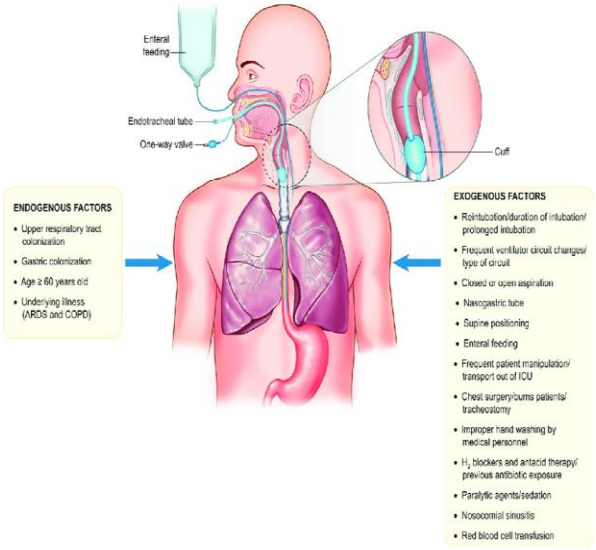

Figure 2: "Main endogenous and exogenous risk factors for VAP"

The duration of the mechanical ventilation is especially critical in the interpretation of the VAP occurrence. The longer patients can leave the resuscitation under mechanical ventilation, the more they are exposed to the possible mechanisms that can cause VAP. Thus, the following analysis identifies the issue of whether the ventilation duration and other clinical features of the VAP and the non-VAP groups are different [28].

Table 2. VAP Status Among Mechanically Ventilated Patients

VAP status	Frequency (n)	Percentage (%)
VAP developed	52	26.0

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ISSN: 0937-583x Volume 91, Issue 8 (Aug-2026)
https://musikinbayern.com DOI https://doi.org/10.15463/gfbm-mib-2026-563

No VAP	148	74.0
Total	**200**	**100.0**

4.4 Comparison Between VAP and Non-VAP Groups

Table 3 presents the comparison of the selected characteristics of patients that developed VAP and those who did not. The mean duration of mechanical ventilation in patients who developed VAP was higher compared to patients who did not develop VAP in the illustrative analysis. This mean was around 14.7 days in the VAP group and 7.8 days in the non-VAP group.

Likewise, patients with VAP had a longer length of stay in ICUs. This observation might indicate the effects of both VAP and even the more severe illness of patients with long-lasting intensive care.

Patients that developed VAP also had higher chances of re-intubation. This could be of clinical importance since airway manipulation may lead to more exposure to microorganisms and disrupt normal airway protection when repeated [29].

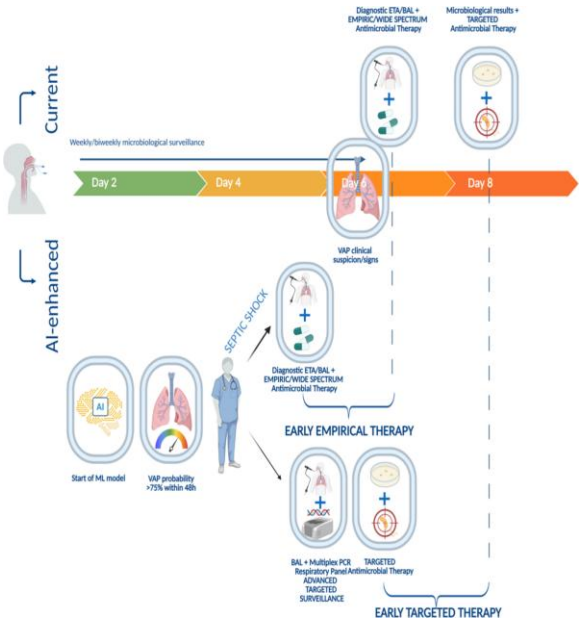

Figure 3: "Real-time prediction of ventilator-associated pneumonia onset in ICU"

The proportion of patients with underlying chronic respiratory disease is also higher in the VAP group as illustrated in the analysis. Nevertheless, the fact that there is an observed difference does not imply that the variable is causal of VAP independently. More multivariate analysis is thus needed to explain the concomitant effect of multiple risk factors.

Table 3. Comparison of Selected Characteristics Between VAP and Non-VAP Groups

Variable	VAP group (n=52)	Non-VAP group (n=148)	Illustrative p-value
Age, mean ± SD (years)	62.1 ± 15.7	59.0 ± 16.6	0.240
Male, n (%)	34 (65.4 %)	82 (55.4%)	0.220

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≥1 comorbidity, n (%)	42 (80.8 %)	100 (67.6%)	0.080
Chronic respiratory disease, n (%)	18 (34.6 %)	26 (17.6%)	0.012
Re-intubation, n (%)	17 (32.7 %)	21 (14.2%)	0.003
Mechanical ventilation, mean ± SD (days)	14.7 ± 7.4	7.8 ± 5.4	<0.001
ICU stay, mean ± SD (days)	19.1 ± 9.2	11.4 ± 6.9	<0.001
Enteral feeding, n (%)	44 (84.6 %)	107 (72.3%)	0.070
Sedation, n (%)	47 (90.4 %)	116 (78.4%)	0.050

The representative outcomes indicate that the length of mechanical ventilation, the period of stay in the ICU, re-intubation and chronic respiratory disease might be factors of particular relevance. However, the same does not apply to age and sex which exhibit weaker evidence of an association in this example.

4.5 Analysis of Potential Risk Factors

The second step of analysis takes into account the correlation between the risk factors that have been chosen and the formation of VAP. The logistic regression is suitable since the Y variable is categorical (two categories of development of VAP and the absence of VAP).

The illustrative unadjusted analysis showed that long-term mechanical ventilation was correlated with the increased probability of VAP. Another statistical association was found between inhaling respiratory diseases (re-intubation) and the occurrence of VAP. These results confirm the preliminary comparison between two groups.

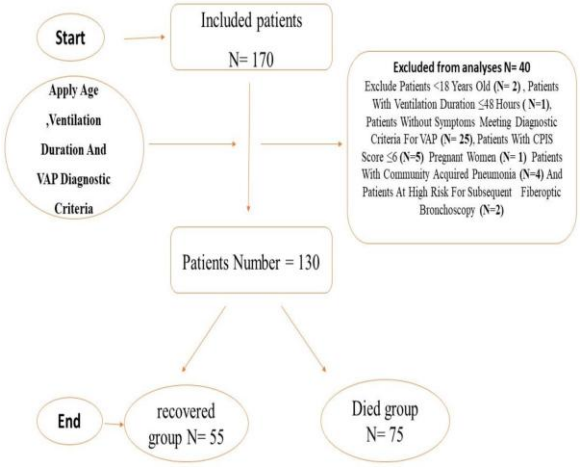

Figure 4: "Exploring Ventilator-Associated Pneumonia"

Nonetheless, one of the problems of clinical research is confounding. As a case in point, patients that are severely ill might need ventilators longer and can also be at a greater risk of being infected. Thus, correlation should not

necessarily be seen as a causal relationship between the duration of ventilation and VAP. Multivariate regression is used to find out whether there are associations left after other variables are considered.

Table 4. Illustrative Univariate Logistic Regression Analysis of Potential VAP Risk Factors

Risk factor	Odds Ratio (OR)	95 % CI	Illustrative p-value
Age	1.01	0.99–1.03	0.240
Male sex	1.52	0.76–3.04	0.230
≥1 comorbidity	2.02	0.91–4.48	0.083
Chronic respiratory disease	2.48	1.18–5.21	0.017
Re-intubation	2.93	1.36–6.31	0.006
Mechanical ventilation >10 days	4.21	2.02–8.77	<0.001
Enteral feeding	2.05	0.91–4.61	0.083
Sedation	2.58	0.98–6.78	0.055

The example univariate results show that patients who were on mechanical ventilation longer than ten days were significantly more likely to develop VAP. Statistically significant relationships were also found between re-intubation and chronic respiratory disease. In this example, age, and sex were not statistically significant.

4.6 Multivariable Analysis and Clinical Predictors

The multivariable logistic regression model was then taken into consideration to determine the factors which are independently related to VAP. Variables that were clinically relevant and/or showed signs of association during initial analysis were included into the model.

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Table 5 illustrates that after the adjustment of other factors, the prolonged mechanical ventilation continued to be a significant independent predictor. The odds ratio of developing VAP among patients who had over 10 days ventilation was about threefold those patients who had 10 days or less ventilation in the illustrative model [30].
VAP was also related independently to re-intubation. Adjustment revealed a less significant yet potentially significant association with chronic respiratory disease. The results indicate that potentially, more significant predictors are airway-related factors and extended exposure to mechanical ventilation rather than demographic characteristics per se.

Table 5. Illustrative Multivariable Logistic Regression Predicting VAP

Predictor	Adjusted OR	95% CI	Illustrative p-value
Age	1.01	0.98 – 1.03	0.420
Male sex	1.32	0.62 – 2.80	0.470
≥1 comorbidity	1.61	0.68 – 3.80	0.280
Chronic respiratory disease	2.14	1.01 – 4.55	0.047
Re-intubation	2.61	1.15 – 5.92	0.022
Mechanical ventilation >10 days	3.48	1.61 – 7.51	0.002
Enteral feeding	1.42	0.60 – 3.36	0.420
Sedation	1.77	0.66 – 4.72	0.250

The explanatory multivariate results thus suggest that long-term mechanical ventilation and re-intubation are relevant independent predictors of VAP, and chronic respiratory disease could also be a risk factor. Independent associations do not exhibit statistically significant changes in the illustrative adjusted model with regards to age, sex, enteral feeding and sedation.

4.7 Overall Interpretation of Findings

Altogether, the demonstrative results indicate that the association with VAP is stronger based on factors related to the length and the intricacy of mechanical ventilation than elementary demographic features. This higher prevalence of VAP in patients who received such prolonged mechanical ventilation is clinically plausible since the prolonged presence of an endotracheal tube can cause natural airway defence mechanisms and create more time and space to allow bacterial colonization and aspiration. The re-intubation association is also to be taken into consideration since a

second time airflow manipulation could threaten the risk of contamination and aspiration. Long-term respiratory illness can also predispose as such patients could possess compromised respiratory, and less pulmonary reserve.
However, the results are to be taken at face value. The correlation with a clinical factor and VAP does not imply causation. There are also some risk factors that could serve as indicators of how severe a disease is. In addition, the practices of ICU, infection-control measures, prescribing of antibiotics, patients and the diagnosis of VAP may be of interest here and can affect the observed ones.

4.8 Summary

The findings provided in this chapter show that different characteristics can be studied to pinpoint the possible risk factors of VAP by using demographic, clinical and ventilation-related factors. The illustrative analysis indicates that prolonged mechanical ventilation, re-intubation and chronic respiratory disease are risk factors of the VAP, and prolonged ventilation and re-intubation remain a significant risk factor on controlling variables.
But the ultimate terminology should be purely patient data and statistical results. Before the results are applied to writing an academic dissertation, the illustrative values in this chapter must then be substituted with the actual frequencies, percentages, means, odds ratios, confidence intervals and p-values of the study.

V. CONCLUSION

Ventilator-Associated Pneumonia (VAP) has been a significant problem among patients under mechanical ventilator care due to its tendency to elevate morbidity, intensive care unit (ICU) stay duration, the length of mechanical ventilation and worse patient outcome. This research explored the key risk factors and clinical predictors of VAP in mechanically ventilated patients, and specifically examined demographic, clinical, treatment related and ventilation related factors. The results show that VAP is a multifactorial phenomenon as opposed to a patient-specific outcome. Long-term mechanical ventilation was a key variable that contributed to the risk of VAP. Other possible effects of longer duration of invasive ventilation include the possibility of airway colonization, disruption and destruction of normal respiratory defence mechanisms via aspiration and damage to normal respiratory secretions. Re-intubation was also found as an critical clinical predictor, which might be due to repeated airway manipulation, which could increase exposure to microorganisms and airway protection. Divergent respiratory illness has the potential to add additional vulnerability to patients who are critically ill.

The analysis also shows the relevance of a differentiation to distinguish between simple associations and independent clinical predictors. Although some of the characteristics can seem more prevalent in the case of patients developing the VAP, they need to be analyzed using a multivariate analysis on whether they are still significant following other patient and treatment traits. This method has a deeper clinical measurement of the risk of VAP. Possible significance of early detection of high-risk patients under mechanical ventilation is pointed out in the study. Specifically, patients who have to use prolonged ventilation or be intubated on a regular basis may indicate infection-preventive measures, which should be most cautious. Evidence-based practices of airway management and ICU could thus help in minimizing complications that can be avoided. In general, the knowledge of the risk factors and clinical predictors of VAP can inform more specific measures to prevent it and enhance clinical judgments. Further studies are advised to employ larger multi-centre data, standardized diagnostic measures and validation prediction models to determine these associations as well as increase prediction power of a potential patient with the highest risks of developing VAP.

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