

Chapter 09 / Capítulo 09

*Screening, Diagnosis, and Prevention in Clinical Practice:
Evidence from Argentine and Latin American Medicine
(English Version)*

ISBN: 978-9915-704-33-3

DOI: 10.62486/978-9915-704-33-3.Ch09

Pages: 117-136

©2026 The authors. This is an open access book distributed under the terms of the Creative Commons Attribution (CC BY) 4.0 License.

Hospital-acquired pneumonia: a narrative review

Neumonía Intrahospitalaria: una revisión narrativa

Katherin Anais Vásquez Lomas¹ ✉, Susy Caroly Tangoa Pérez¹, Dayanne Alexandra Vela Pinedo¹, Jesús Sebastián Flores Tuesta¹, Wilter C. Morales García² ✉, Víctor Álvarez-Manrique¹, Mardel Morales-García³

¹Escuela Profesional de Enfermería, Facultad de Ciencias de la Salud, Universidad Peruana Unión. Tarapoto, Perú.

²Dirección General de Investigación, Universidad Peruana Unión. Lima, Perú.

³Unidad de Salud Pública, Escuela de Posgrado, Universidad Peruana Unión. Lima, Perú.

*Corresponding author: Wilter C. Morales García ✉

ABSTRACT

Objective: to conduct a literature review on hospital-acquired pneumonia through factors, treatment, and prevention.

Method: as data sources, Scopus, SciELO, PubMed, Google Scholar were used. Data selection: Documents were selected and analyzed under a critical literature review, considering inclusion and exclusion criteria.

Results: a corpus of 19 articles was analyzed, including 6 retrospective studies, 4 systematic reviews, 3 prospective studies, 2 narrative studies, 2 cross-sectional studies, 1 qualitative study, 1 observational study, 1 meta-analysis, one multiple logistic regression analysis, one longitudinal study, one analytical review, one phase III trial, one literature review, and one quantitative study. The population studied included pediatric patients, young people, adults, and the elderly. The studies were conducted in various countries, such as Spain, China, Mexico, Brazil, Canada, the Philippines, the United States, India, Egypt, Peru, France, Romania, Italy, Argentina, Oman, and the Czech Republic, each of which contributed a unique perspective to the research. Two articles addressed neurological factors, 11 focused on manifestations, and 6 dealt with predictive factors. The clinical condition of the patients in the studies, 8 articles analyzed the results of acute ischemic stroke (AIS), severe TBI, craniofacial trauma, moderate TBI, chest trauma, pulmonary contusion, acute diseases, hip fracture, chronic lung disease, periodontal disease, poor oral health, and comorbidities in terms of socioeconomic status. The studies were conducted in countries with diverse resources and incomes, reflecting improved access to effective diagnosis of hospital-acquired pneumonia.

Conclusion: NIH and its mortality rate are associated with different factors, with timely diagnosis and appropriate treatment being essential to avoid complications. The collaboration of nursing staff and multidisciplinary collaboration is highlighted to achieve better control and reduce the incidence of nosocomial infections.

Keywords: Factor, treatment, prevention.

RESUMEN

Objetivo: realizar una revisión de literatura sobre la neumonía intrahospitalaria a través de factores, tratamiento y prevención.

Método: como fuentes de datos se emplearon Scopus, SciELO, PubMed, Google Scholar.

Selección de datos: Los documentos fueron seleccionados y analizados bajo una revisión crítica de literatura tomando en cuenta los criterios de inclusión y de exclusión.

Resultados: se analizó un corpus de 19 artículos de los cuales 6 estudios retrospectivos, 4 revisiones sistemáticas, 3 estudios prospectivos, 2 estudios narrativos, 2 transversales, 1 estudio cualitativo, 1 observacional, 1 metaanálisis, 1 análisis de regresión logística múltiple, 1 longitudinal, 1 revisión analítica, 1 ensayo de fase III, 1 revisión de literatura, 1 cuantitativo. La población estudiada incluye pacientes pediátricos, jóvenes, adultos y ancianos. Los estudios se desarrollaron en diversos países, tales como España, China, México, Brasil, Canadá, Filipinas, Estados Unidos, India, Egipto, Perú, Francia, Rumanía, Italia, Argentina, Omán, Republica Checa, cada uno aportó una perspectiva única a la investigación. Se identificaron 2 artículos que abordaron factores neurológicos, 11 que se enfocaron en manifestaciones y 6 que trataron sobre factores predictivos. La condición clínica de los pacientes de los mencionados estudios, 8 artículos analizaron los resultados accidente cerebro vascular isquémico agudo (AIS), TEC severo, trauma craneo facial, TEC moderado, traumatismo torácico, contusión pulmonar, enfermedades agudas, fractura de cadera, enfermedad pulmonar crónica, enfermedad periodontal, mala salud bucodental y comorbilidades en cuanto al nivel socioeconómico, los estudios se realizaron en países de diversos recursos e ingresos, reflejando la mejora al acceso de la eficacia en el diagnóstico de la neumonía intrahospitalaria.

Conclusión: la NIH y su índice de mortalidad están asociados a diferentes factores, siendo el diagnóstico oportuno y el tratamiento adecuado fundamentales para evitar complicaciones. Se resalta la colaboración del personal en enfermería y la colaboración multidisciplinaria para realizar un mejor control que disminuya la incidencia de infecciones nosocomiales.

Palabras clave: Factor; Tratamiento; Prevención.

INTRODUCTION

Hospital-acquired pneumonia (HAP) is the most common nosocomial infection, with variable incidence rates depending on age, sex, and comorbidities. It is associated with higher mortality, especially in ventilated patients, and leads to increased costs and hospital stays (Lopez-De-andres et al., 2021). It accounts for up to 25 % of hospital infections. It is the second most common infection in ICUs, being the leading cause of mortality and intensive use of resources, especially in patients with serious illnesses (Mazloomirad et al., 2021) (W. Chen et al., 2025). Morbidity and mortality increase in older adults due to immune deterioration and complex diagnoses; patients with dementia are 2,5 times more at risk, also generating a significant economic burden (Wang et al., 2022; W. Chen et al., 2025).

Healthcare-associated pneumonia (HCAP) and ventilator-associated pneumonia (VAP) pose challenges and diagnostic issues (Wang et al., 2022) because delays in microbiological results require early empirical treatment, which must be appropriate and prudent to reduce mortality, avoiding the indiscriminate use of new antibiotics (Erich et al., 2022) (Zaragoza et al., 2020). It is essential to correctly identify patient-related risk factors and procedures in order to choose the appropriate treatment, as inadequate management significantly increases mortality (Zaragoza et al., 2020).

The spread of multidrug-resistant Gram-negative pathogens, such as *Pseudomonas aeruginosa*, *Acinetobacter* spp., and methicillin-resistant *Staphylococcus aureus*, complicates treatment, especially in mechanically ventilated patients, where the endotracheal tube is a

critical reservoir (Gatti et al., 2022; Mazloomirad et al., 2021).

Some studies explored preventive strategies for non-ventilator-associated NHA by assessing the risks of aspiration and oral aspiration, the role of mobilization and physical therapy, environmental factors, and vaccination (Quarton et al., 2024). Research has also been conducted on HA-resistant pathogens such as Enterobacteriaceae and non-fermenting Gram-negative bacteria, as well as on initial empirical treatment, which has serious complications when approved antibiotics such as ceftobiprole, ceftolozane-tazobactam, ceftazidime-avibactam, meropenem-vaborbactam, and cefiderocol are used against multidrug-resistant Gram-negative pathogens (Bassetti et al., 2022), with Gram-negative bacteria being the most commonly reported organisms overall, including *Acinetobacter* species (particularly *A. baumannii*) (Abdalla et al., 2023).

The treatment of hospital-acquired pneumonia (HAP) usually includes two main classes of antibiotics: third-generation cephalosporins and fluoroquinolones, with ceftriaxone and levofloxacin being the most widely used antibiotics in their respective classes (Hasan Delina, 2024). That is why guidelines recommend treatment with broad-spectrum antibiotics that cover both Gram-positive and Gram-negative bacteria (Quarton et al., 2024). Conventional oxygen therapy and intravenous oxygen therapy (NRS) generally reduce reintubations and VAP, decreasing hospital mortality and ICU stays, thereby reducing the rate of post-extubation respiratory failure in ICU patients (Boscolo et al., 2023).

The FP panel (multiplex molecular syndromic testing) enables earlier reduction of antibiotic therapy than standard cultures, improving care for patients with hospital-acquired pneumonia and facilitating rapid access to antimicrobial information (Erich et al., 2022). The ENVIN-HELICS report (National Surveillance Study of Nosocomial Infection and Helices) provides a comprehensive overview of bacterial resistance, as choosing an inappropriate antibiotic against multidrug-resistant organisms (MDROs) is the most important and modifiable prognostic factor (Zaragoza et al., 2020). Diagnosis is improved by combining PCT, PCR, and sTREM-1 or HBP markers (Wang et al., 2022).

Hypoalbuminemia and diseases such as Alzheimer's and type 2 diabetes increase the risk of pneumonia, while gender disparities require attention (W. Chen et al., 2025; Lopez-De-andres et al., 2021). For treatment, intravenous fosfomycin improves the eradication of resistant *Pseudomonas aeruginosa*, and the most common pathogens in ventilator-associated pneumonia include *Acinetobacter baumannii*, *Staphylococcus aureus*, and *Escherichia coli* (Gatti et al., 2022; Mazloomirad et al., 2021).

For this reason, this study aims to conduct a literature review on hospital-acquired pneumonia, based on factors, treatment, and prevention.

METHOD

A comprehensive narrative review on hospital-acquired pneumonia was conducted to explore the existing scientific literature, consulting the following databases: Scopus, SciELO, PubMed, and Google Scholar. To refine the search, the terms "AND" were used. In addition, the Boolean operator AND was used to refine and broaden the search scope, and the search period was extended from August to November 2025, with articles published between 2020 and 2025 included in the review.

This search covered texts written in any language, specifically excluding case reports, interviews, letters to the editor, theses, and books, due to their less empirical nature or specific focus. Within the aforementioned databases, a total of 498 043 articles were initially identified using the designed search thread. Of these, 457,301 corresponded to the SciELO database, 8 493 to Scopus, 26 100 to Google Scholar, and 6 149 to PubMed. Next, 0 duplicate articles were removed. Subsequently, 11 articles that did not align with the study objective and another 498 043 that did not meet the established inclusion criteria were excluded. As a result of this filtering and selection process, a final corpus of 19 articles relevant to the review was obtained.

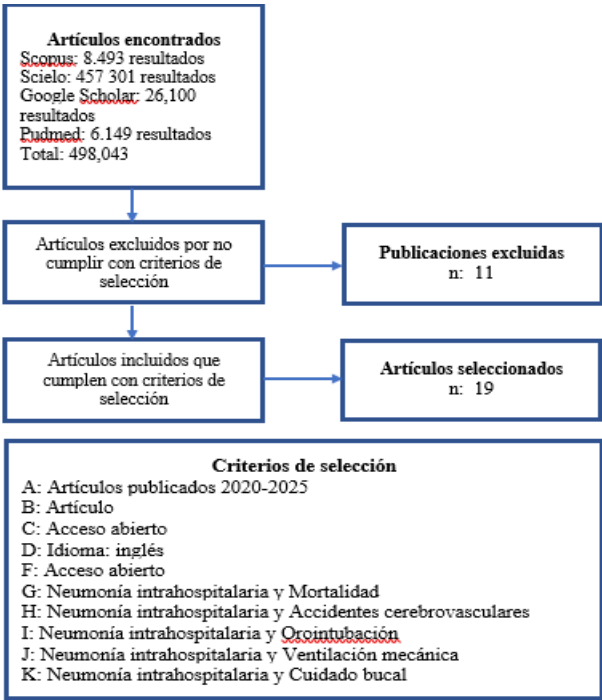


Figure 1. Flow diagram

RESULTS

A corpus of 19 articles was compiled, of which 6 were retrospective studies, 4 were descriptive, 4 were systematic reviews, 3 were prospective, 2 were narrative, 2 were cross-sectional, 1 was qualitative, 1 was observational, 1 was a meta-analysis, 1 was a multiple logistic regression analysis, 1 was longitudinal, one analytical study, one phase III trial, one literature review, and one quantitative study. The population studied includes pediatric patients, young people, adults, and older adults up to 90 years of age. The studies were conducted in various countries, such as Spain, China, Mexico, Brazil, Canada, the Philippines, the United States, India, Egypt, Peru, France, Romania, Italy, Argentina, Oman, and the Czech Republic, providing perspectives from different social, economic, and cultural realities. Two articles addressed neurological factors, 11 focused on manifestations, and 6 dealt with predictive factors. The clinical condition of the patients in the studies, 8 articles analyzed the results of acute ischemic stroke (AIS), severe TBI, craniofacial trauma, moderate TBI, chest trauma, pulmonary contusion, acute illnesses, hip fracture, chronic lung disease, periodontal disease, poor oral health, and comorbidities in terms of socioeconomic status. The studies were conducted in countries with varying resources and incomes, reflecting improved access to effective diagnosis of hospital-acquired pneumonia.

Table 1. Results table

Study title	Methodology	Objective/sample	Main results
Ten issues that need to be updated in nosocomial or hospital-acquired pneumonia: an expert review (Candel, F. J, et al., 2023)	Narrative reviews	Review the most important issues in the approach to nosocomial pneumonia for adequate treatment.	It is concluded that optimal treatment of HAP requires an interprofessional team composed of multiple specialists to ensure current, effective, and safe treatment.
Construction and evaluation of a nomogram model for predicting the risk of hospital-acquired pneumonia in elderly patients with acute ischemic stroke (Huang, et al., 2025)	Retrospective study	Develop and validate an easy-to-use model for predicting the risk of hospital-acquired pneumonia (HAP) in elderly patients with acute ischemic stroke (AIS). Sample: 2,861 elderly patients with AIS	HAP is high risk for those who are elderly, have cardiovascular accidents, stress hyperglycemia (SHR), smoke, and have dysphagia.
Hospital-acquired pneumonia associated with mechanical ventilation in a hospital in the state of Tabasco, Mexico. (Solórzano M, et al., 2020)	Quantitative, descriptive, cross-sectional, retrospective, and observational.	To evaluate cases of hospital-acquired pneumonia in mechanically ventilated patients (NAVM) in the emergency department of the Gustavo Adolfo Rovirosa Pérez Regional High Specialty Hospital from January 2016 to December 2017. Sample: Men and women, ages ranging from 18 to 86 years.	The development of NAVM is related to the duration of exposure to orotracheal intubation.
Association of antimicrobial use and the incidence of hospital-acquired pneumonia in critically ill trauma patients with lung contusion: an observational study (Bassi, E, et al., 2024)	Retrospective review	To evaluate the relationship between antibiotic use and the incidence of hospital-acquired pneumonia in patients with pulmonary contusions. Sample: Of the 2,040 ICU admissions, 273 patients had chest trauma with CT scans available, of whom 172 had pulmonary contusions.	Each day of antibiotic use is associated with an increased risk of pneumonia caused by resistant bacteria.
“Empirical antibiotic regimens in adults with non-ventilator-associated hospital-acquired pneumonia: a systematic review and network meta-analysis of randomized controlled trials.” (Ghadimi et al., 2024)	Systematic	To compare the effectiveness and safety of alternative empirical antibiotic regimens in CAP using a network meta-analysis.	Piperacillin-tazobactam may be among the most effective antibiotics for reducing failure of empirical treatment of ventilator-acquired pneumonia (VAP).

Evaluation of knowledge and practices of Open Access implementation of the package of measures for ventilator-acquired pneumonia (VAP) in the intensive care unit of a private hospital (Abad, et al., 2021)	Descriptive study using quantitative and qualitative methods	The existing knowledge, practices, and adherence of nurses and infection control prevention (ICP) specialists for the prevention of VAP in the intensive care unit (ICU) are evaluated	As a preventive measure, formal training and interactive educational sessions should be provided to healthcare professionals, such as nursing staff, so that they are familiar with VAP prevention measures
Descriptive Epidemiology and Outcomes of Nonventilated Hospital-Acquired, Ventilated Hospital-Acquired, and Ventilator-Associated Bacterial Pneumonia in the United States, 2012-2019 (Zilberberg, M, et al., 2022)	Retrospective cohort	We examined the epidemiology and outcomes of patients with ventilator-associated bacterial pneumonia and hospital-acquired bacterial pneumonia. Sample: Two hundred fifty-three acute care hospitals in the United States that contributed data (including microbiology) to the Premier database, 2012-2019.	Patients with hospital-acquired bacterial pneumonia who subsequently required ventilation have been shown to have higher mortality than those who did not require ventilation or who had ventilator-associated bacterial pneumonia.
Factors Predicting non-ventilated hospital-acquired pneumonia: systematic review and meta-analysis (S.A. Lukasewicz Ferreira, et al., 2021)	Systematic review and meta-analysis	To identify, quantify, and summarize the predictive factors of NVHAP in adult patients admitted to non-intensive care units as determined by previous observational studies. Sample: Nosocomial pneumonia accounts for approximately 15 % to 20 % of all hospital infections, and more than two-thirds occur without mechanical ventilation.	Identifying predictive factors will make it more likely to determine whether a patient will develop NHAVP.
Risk factors for hospital-acquired pneumonia in hip fracture patients: a systematic review and meta- . (Wel Yao, et al., 2024)	Systematic review	This study aimed to systematically evaluate the incidence and risk factors of hospital-acquired pneumonia (HAP) in patients with hip fractures using a meta-analysis.	Patients with hip fractures are at increased risk of developing postoperative HAP, leading to hospital stays and adverse clinical outcomes.
Ventilator-associated Pneumonia: A Prospective Observational Study (Natarajan, K, et al., 2024)	A multiple logistic regression analysis was performed	The primary objectives were to determine the occurrence and clinical outcome of VAP in the intensive care unit (ICU), while the secondary objectives were to identify the risk factors and microbiological profile of VAP.	Prolonged mechanical ventilation and chronic lung disease were significantly associated with VAP, and it is necessary to rigorously implement VAP measure packages adhering to infection control protocols.

“Hospital-Acquired Pneumonia Pattern in the Intensive Care Units of a Governmental Hospital: A Prospective Longitudinal Study” (Yakoub, M, et al., 2023)	Prospective longitudinal study	To quantify the incidence of HAP, determine the predictors of HAP, calculate the hazard ratio for HAP-related mortality, and identify the different risk factors that contribute to mortality.	The high mortality rate was strongly correlated with reintubation, ICU stay ≥ 5 days, diabetes mellitus, and neurological diseases.
“Epidemiological characteristics of hospital-acquired pneumonia in an internal medicine department at the Guillermo Almenara Irigoyen Hospital in Lima, Peru.” (Len-Chahua, C et al., 2016)	Descriptive, retrospective	To determine the epidemiological characteristics of patients with hospital-acquired pneumonia (HAP) in an internal medicine department. Sample: Twenty-six patient medical records were evaluated.	Mortality in patients with HAP is associated with advanced age with cerebrovascular and neoplastic comorbidities and the use of a nasogastric tube. Factors: Advanced age, cerebrovascular disease, neoplastic disease, use of a nasogastric tube, and inhibitors.
“Potential Impact of Rapid Multiplex PCR on Antimicrobial Therapy Guidance for Ventilated Hospital-Acquired Pneumonia in Critically Ill Patients, A Prospective Observational Clinical and Economic Study” (Guillotín, F, et al., 2022)	Analytical review	To investigate the potential impact of the FilmArray®Pneumonia plus Panel (FAPP) syndromic multiplex on antimicrobial treatment guidance for patients with ventilator-associated pneumonia (VHAP). SAMPLE: Treatment failure was predicted in 3 % of cases with FAPP results versus 11 % observed in real life.	The use of FAPP in patients with VHAP may reduce the use of broad-spectrum antimicrobials without increasing the risk of microbial treatment failure.
“A phase III, randomized, controlled noninferiority trial to study the efficacy and safety of imipenem/cilastatin/relebactam (IMI/REL) vs piperacillin/tazobactam (PIP/TAZ) in patients with hospital-acquired bacterial pneumonia (HABP) or ventilator-associated bacterial pneumonia (VABP)” (Li, J, et al., 2025)	Phase III, multicenter, double-blind, active-controlled, parallel-group, randomized noninferiority trial	Imipenem/cilastatin/relebactam (IMI/REL) is a combination of β -lactams and β -lactamase inhibitors effective against Gram-negative pathogens. The efficacy and safety of IMI/REL was studied in critically ill adults with NIH	IMI/REL was associated with favorable safety and efficacy outcomes in critically ill patients with HABP and VABP
Hospital-Acquired Pneumonia and Ventilator-Associated Pneumonia: A Literature Review (Mihnea M, et al., 2024)	narrative and systematic review	This review article provides an overview of recently approved terminology for nosocomial pneumonia, as well as risk factors, biomarkers, diagnostic methods, and new treatment options that may guide the management of this spectrum of infections.	Treatment with cefiderocol in critically ill patients with multidrug-resistant Gram-negative infections is associated with increased mortality and side effects such as hypokalemia, hypomagnesemia, atrial fibrillation, elevated liver enzymes, and candidiasis.

Preventive oral hygiene and ventilator-associated pneumonia in the pediatric intensive care unit (Alí Munive, A et al., 2013)	Literature reviews	The objective of this literature review is to investigate whether improved oral hygiene could influence the onset of nosocomial pneumonia in children.	Oral care mitigates the proliferation of bacteria in the bloodstream, indicating the effectiveness of mechanical and pharmacological interventions in reducing or preventing the onset of VAP.
Epidemiological profile of patients with ventilation-associated pneumonia in a teaching hospital (Broggiani, I, et al., 2024)	Cross-sectional, retrospective, documentary with a quantitative approach.	This research aims to identify the epidemiological profile of patients with ventilator-associated pneumonia in the intensive care unit of a teaching hospital	There is still a need to develop prevention strategies to reduce the incidence of ventilator-associated pneumonia in critically ill patients.
Nurses' compliance with the ventilator-associated pneumonia prevention bundle and its effect on patient outcomes in intensive care units (Al-Harthi, F, et al, 2025)	This prospective descriptive correlational study	The study investigated the rate of VAP and nurses' compliance with the VAP bundle, as well as the correlation between nurses' compliance with the VAP bundle and key patient-related outcome factors.	The role of nurses in implementing NAV care procedures has a significant impact on the clinical outcomes of mechanically ventilated patients.
Hospital-acquired pneumonia in ICU patients (Radovan U, et al., 2023)	Prospective study.	To evaluate the effect of initial antibiotic therapy on mortality in patients with hospital-acquired pneumonia (HAP) by analyzing bacterial pathogens and their resistance to antimicrobial agents	In hospital practice at the ward level, HAP is an overused diagnosis that may be inaccurate in 35 % of cases when objective radiological criteria are applied. Radiologically confirmed HAP represents a distinct clinical and microbiological phenotype.

DISCUSSION

The development of the findings has enabled the identification of factors, treatments, and diagnoses related to hospital-acquired pneumonia, which other sources will analyze.

Factors

Increased mortality in patients with NIH is associated with advanced age, use of a nasogastric tube (León César, 2016), cerebrovascular accidents, stress hyperglycemia, smoking, dysphagia (Huang et al., 2025), hip fracture (Fally et al., 2024), diabetes mellitus, as well as reintubation (Yakoub et al., 2023), time of exposure to orotracheal intubation (Solórzano-Martínez et al., 2020) and prolonged mechanical ventilation (Natarajan et al., 2025), these being the factors with the highest probability of death (Zilberberg et al., 2022). It is therefore imperative to identify the factors that lead to the development of NIH (Lukasewicz Ferreira et al., 2022) and, above all, the importance of the appropriate use of antibiotics (Bassi et al., 2024).

Mortality

Following cardiac surgery, it was determined that the greatest risk of death was from bacteremia pneumonia (Massart et al., 2022), which shows that it is important to identify individual risk factors (Ukai et al., 2023) such as advanced age, cerebrovascular and neoplastic comorbidities, and the use of a nasogastric tube (León César, 2016) through studies that determine pathogens (Poovieng et al., 2022) and the number of days in the ICU (Pei et al., 2023) in order to prevent mortality and its causes (Oznur et al., 2021).

Strokes

The identification of key factors such as stroke severity (Abujaber et al., 2025), patient age, malnutrition (Guo et al., 2021), dysphagia, and antimicrobial resistance is of great concern (Wattoo et al., 2021). It is important to characterize the oral microbiota (Ren et al., 2023) and develop a monogram that helps professionals make timely decisions for each patient (Huang et al., 2025).

Orointubation

Ventilator-associated pneumonia (VAP) is associated with the duration of orotracheal intubation and prolonged endotracheal intubation, which are considered its main causes (Solórzano-Martínez et al., 2020). (Peter R Lichtenhal, 2025), This procedure causes respiratory complications, requiring the development of new tube designs that ensure a safe airway (Ramírez et al., 2024). In addition, post-extubation dysphagia is common in ICU patients (Yu et al., 2024), and patients using non-invasive ventilation should be monitored for the first 24 hours to assess the need for intubation (Abe et al., 2023).

Mechanical ventilation

Mechanical ventilation is essential in critically ill patients, but its prolonged use is associated with complications such as ventilator-associated pneumonia (VAP) and chronic lung disease (Natarajan et al., 2025). Its management requires an understanding of pulmonary physiology and the patient's pathology to improve the quality and efficiency of intensive care (Karunarathna et al., 2025; Xu et al., 2025). In addition, early mortality and ventilation are associated with higher mortality in the ICU (Yao et al., 2024). Therefore, implementing standardized management practices that include antibiotic prevention and appropriate antibiotic use improves outcomes and reduces microbial resistance (Miron et al., 2024).

Treatment

Within treatment, drugs such as piperacillin-tazobactam are among the most effective

antibiotics (Ghadimi et al., 2024), while Imipenem/Cilastatin/Relebactam (IMI/REL) shows favorable results (Li et al., 2025). In contrast, the use of cefiderocol in critically ill patients results in side effects. (Miron et al., 2024) The use of FilmArray® Pneumonia Plus Panel (FAPP) (Guillotin et al., 2022) and the involvement of multiple specialists ensure effective and safe treatment (Candel et al., 2023).

Cefiderocol

Patients with (NAH) and (NAR) require immediate attention and antibiotics due to the increase in nosocomial infections that delay treatment and increase mortality (Kanj et al., 2022). In addition, microbial resistance hurts patients with limited options (Kanj et al., 2022). Although treatment with cefiderocol in critically ill patients is associated with higher mortality and side effects (Miron et al., 2024), its long-term use should be considered in vulnerable patients such as those who are immunocompromised (Plaisance et al., 2024) even though cefiderocol is still in the preclinical phase against pneumonia due to the resistance of Gram-negative bacteria (Rashid et al., 2023).

Piperacillin-tazobactam

The selection of initial empirical antibiotic treatment for hospital-acquired pneumonia (HAP) should be based on each antibiotic's characteristics and the patient's condition (Kim et al., 2023). In this case, piperacillin-tazobactam is not inferior to other antibiotics, as they are well tolerated (Titov et al., 2021), and could be effective in reducing the failure of empirical treatment of HAP (Ghadimi et al., 2024), thus being an effective alternative to carbapenems in nosocomial pneumonia (Zha et al., 2022). Furthermore, the combination of cefoperazone-sulbactam is as effective as piperacillin-tazobactam in adults with NAH/NAV (C. H. Chen et al., 2021).

Imipenem/Cilastatin/Relebactam (IMI/REL)

Imipenem/cilastatin/rellebactam (IMI/REL) was associated with favorable safety and efficacy outcomes in critically ill patients with HABP and VABP. (Li et al., 2025) It is an appropriate treatment option, even in critically ill and high-risk patients (Titov et al., 2021). This is a cost-effective treatment option for physicians, given patient risk factors and local epidemiology (Naik et al., 2023). In addition, IMI/REL was effective in carbapenem-resistant KPC and *P. aeruginosa* (Girón et al., 2022), meeting the criteria for non-inferiority compared to PIP/TAZ for 28-day ACM (Li et al., 2025).

FilmArray®Pneumonia

FAPP is a practical tool for rapid etiological diagnosis of NIH in ICU patients (Kamel et al., 2022) because it provides accurate results (Dessajan et al., 2025) and identifies critical organisms and resistance genes (High et al., 2021), enabling physicians to make more informed decisions about antibiotic use (Crémet et al., 2020) without increasing the risk of treatment failure (Guillotin et al., 2022).

Prevention

The role of nurses has a significant impact on clinical outcomes (Al-Harthi et al., 2025) as they conduct training and educational sessions (Abad et al., 2021) on oral care (Munive et al., 2013) in mechanically ventilated patients, preventing contamination of their airways by their own flora (Broggiani Correia Nascimento et al., 2024).

Educational sessions

It is recommended that formal training and interactive educational sessions be provided to nursing staff (Abad et al., 2021) with the help of multidisciplinary collaboration and personalized feedback (Biswas et al., 2024), using the blended learning method (Al-Fazli et al., 2024), thus helping nursing staff to reduce their limited knowledge of the VAP prevention package (Abad et al., 2021) and contributing to reducing VAP rates in hospitalized patients (Kozub et al., 2025).

Oral care

Oral hygiene has been identified as an important factor in the prevention of pneumonia (Tehan et al., 2024) as it mitigates the proliferation of bacteria in the bloodstream, indicating the effectiveness of mechanical and pharmacological interventions, which are considered essential in the standard care of hospitalized patients receiving invasive mechanical ventilation (Ehrenzeller & Klompas, 2024). It is necessary to implement organized strategies and programs to help prevent non-ventilator-associated pneumonia (NV-HAP) and ventilator-associated pneumonia (NAH-NV) (Kozub et al., 2025).

Contamination

The high level of bacterial contamination on objects and instruments that are frequently touched in the ICU contributes to the potential threat of nosocomial infections (Bhatta et al., 2022) due to the presence of MDR ESKAPEE (bacterial group) in these environments, putting the treatment of HAIs (Healthcare-Associated Infections) at risk (Odooyo et al., 2023). Measures to prevent contamination of the respiratory tract by the patient's own flora should also be considered, taking into account contamination of the water system, as infection with *Legionella* (Gram-negative bacteria) can be contracted after inhaling contaminated aerosols (Fang et al., 2023), thus influencing respiratory infection (Cui, Z et al., 2023).

This research on hospital-acquired pneumonia has certain limitations, as it was not possible to cover all existing literature on the subject, which affects the depth and breadth of the analysis. One of the biggest obstacles was the lack of clear, up-to-date information in the scientific literature. Therefore, only some associated and clinical factors were addressed. Despite thorough searches of relevant databases, the studies discussed focus on specific populations and methodologies, whereas this study conducted a more general analysis. For this reason, it is recommended to expand the source review to develop a systematic review in the future. Many of the available articles presented contradictory data, making it difficult to compare and synthesize findings.

These limitations highlight the need for more rigorous research in hospital-acquired pneumonia, which could contribute to a better understanding and management of the disease. Similarly, many articles did not report relevant sociodemographic variables such as socioeconomic status or access to health services, which limits the analysis of possible inequalities or prognostic factors associated with the social context. This lack of standardization and the dispersion of approaches reduces the possibility of generating more robust and generalizable inferences. Therefore, future research should include comparative methodologies and report socioeconomic characteristics to strengthen the validity and applicability of the evidence.

CONCLUSION

Mortality after cardiac surgery is mainly associated with pneumonia bacteremia, highlighting the importance of identifying individual risks such as advanced age, cerebrovascular and neoplastic comorbidities, and the use of a nasogastric tube. The severity of stroke, age,

malnutrition, dysphagia, and antimicrobial resistance are key factors of concern, making it essential to understand the oral microbiota and have a monogram that helps professionals make timely decisions for each patient.

Ventilator-associated pneumonia is mainly due to prolonged intubation, causing respiratory complications, which is why better tube designs are being sought to ensure a safe airway. Mechanical ventilation is vital in critically ill patients, but its prolonged use can cause pneumonia (VAP) and chronic lung disease. Understanding the physiology and pathology of disease improves care, along with standardized prevention and antibiotic management, reducing mortality and antibiotic resistance.

Patients with HAP and CAP require immediate attention and antibiotics due to the increase in nosocomial infections that delay treatment.

The use of cefiderocol in critically ill patients is associated with higher mortality and side effects, so its prolonged use in vulnerable patients should be evaluated, even though it is still in the preclinical phase against Gram-negative bacterial pneumonia. Initial empirical antibiotic treatment for hospital-acquired pneumonia (HAP) should be based on the antibiotic's properties and the patient's condition; cefoperazone-sulbactam is as effective as piperacillin-tazobactam in adults with HAP or VAP. Imipenem/cilastatin/relebactam (IMI/REL) has demonstrated safety and efficacy in critically ill patients with HABP and VABP, making it a suitable option even in high-risk cases. FAPP is a practical tool for rapid etiological diagnosis of NIH in ICU patients, facilitating informed antibiotic decisions.

Formal training of nursing staff through blended learning (BL) and multidisciplinary collaboration is recommended to reduce healthcare-associated pneumonia (HAP) rates in patients. Oral hygiene is key to preventing pneumonia by limiting bacterial proliferation, along with mechanical and pharmacological interventions. Organized strategies are necessary to prevent both non-ventilator-associated pneumonia (NV-HAP) and ventilator-associated pneumonia (NAH-NV). In addition, high bacterial contamination of ICU objects, including MDR ESKAPEE strains, poses a threat to nosocomial infection control. The water system must be monitored, as inhalation of contaminated aerosols can cause *Legionella* infections.

REFERENCES

- Abad, C. L., Formalejo, C. P., & Mantaring, D. M. L. (2021). Assessment of knowledge and implementation practices of the ventilator acquired pneumonia (VAP) bundle in the intensive care unit of a private hospital. *Antimicrobial Resistance and Infection Control*, 10(1). <https://doi.org/10.1186/s13756-021-01027-1>
- Abdalla, J. S., Albarrak, M., Alhasawi, A., Al-Musawi, T., Alraddadi, B. M., Al Wali, W., Elhoufi, A., Habashy, N., Hassanien, A. M., & Kurdi, A. (2023). Narrative Review of the Epidemiology of Hospital-Acquired Pneumonia and Ventilator-Associated Pneumonia in Gulf Cooperation Council Countries. *Infectious Diseases and Therapy*, 12(7), 1741-1773. <https://doi.org/10.1007/s40121-023-00834-w>
- Abe, T., Takagi, T., Takahashi, K., Yagi, K., Tsuge, A., & Fujii, T. (2023). Optimal timing for intubation in patients on non-invasive ventilation: A retrospective cohort study. *Health Science Reports*, 6(12). <https://doi.org/10.1002/hsr2.1757>

- Abujaber, A. A., Yaseen, S., Nashwan, A. J., Akhtar, N., & Imam, Y. (2025). Prediction of stroke-associated hospital-acquired pneumonia: Machine learning approach. *Journal of Stroke and Cerebrovascular Diseases*, 34(2). <https://doi.org/10.1016/j.jstrokecerebrovasdis.2024.108200>
- Al-Fazli, H. K. L., Manzari, Z. S., & Al-Jubouri, M. G. A. (2024). Effect of a training package for the prevention of ventilator associated pneumonia using a blended online learning method on the knowledge and performance of nurses working in the intensive care unit. *Journal of Medical Education Development*, 17(54), 89-100. <https://doi.org/10.61186/edc.17.54.89>
- Al-Harthi, F., Al-Noumani, H., Matua, G. A., Al-Abri, H., & Joseph, A. (2025). Nurses' compliance to ventilator-associated pneumonia prevention bundle and its effect on patient outcomes in intensive care units. *Nursing in Critical Care*, 30(3). <https://doi.org/10.1111/nicc.70043>
- Bassetti, M., Mularoni, A., Giacobbe, D. R., Castaldo, N., & Vena, A. (2022). New Antibiotics for Hospital-Acquired Pneumonia and Ventilator-Associated Pneumonia. *Seminars in Respiratory and Critical Care Medicine*, 43(2), 280-294. <https://doi.org/10.1055/s-0041-1740605>
- Bassi, E., Merighi, C. T., Tomizuka, C. I., Guimarães, T., Novo, F. da C. F., Damous, S. H. B., Utiyama, E. M., & Malbouisson, L. M. S. (2024). Association of antimicrobial use and incidence of hospital-acquired pneumonia in critically ill trauma patients with pulmonary contusion: an observational study. *Brazilian Journal of Anesthesiology (English Edition)*, 74(3). <https://doi.org/10.1016/j.bjane.2023.07.011>
- Bhatta, D. R., Koirala, S., Baral, A., Amatya, N. M., Parajuli, S., Shrestha, R., Hamal, D., Nayak, N., & Gokhale, S. (2022). Methicillin-Resistant *Staphylococcus aureus* Contamination of Frequently Touched Objects in Intensive Care Units: Potential Threat of Nosocomial Infections. *Canadian Journal of Infectious Diseases and Medical Microbiology*, 2022. <https://doi.org/10.1155/2022/1023241>
- Biswas, R., Kumar, V., Biswas, R., Ojha, V. S., Kumar, S., & Sarfraz, A. (2024). Eficacia de las intervenciones de mejora la calidad en las practicas de prescripción de antibióticos para la neumonía en un centro de atención terciaria: un estudio prospectivo pre-post intervencionista. <https://doi.org/10.1136/India>
- Boscolo, A., Pettenuzzo, T., Sella, N., Zatta, M., Salvagno, M., Tassone, M., Pretto, C., Peralta, A., Muraro, L., Zarantonello, F., Bruni, A., Geraldini, F., Cassai, A. De, & Navalesi, P. (2023). Noninvasive respiratory support after extubation: a systematic review and network meta-analysis. *European Respiratory Review*, 32(168). <https://doi.org/10.1183/16000617.0196-2022>
- Broggiani Correia Nascimento, I., Ilenke, L. T., & Ivastcheschen Taques, T. (2024). Perfil epidemiológico de pacientes com pneumonia associada à ventilação mecânica de um hospital escola. *Revista de Epidemiologia e Controle de Infecção*, 14(2). <https://doi.org/10.17058/reci.v14i2.19087>
- Candel, F. J., Salavert, M., Estella, A., Ferrer, M., Ferrer, R., Gamazo, J. J., García-Vidal, C., del Castillo, J. G., González-Ramallo, V. J., Gordo, F., Mirón-Rubio, M., Pérez-Pallarés, J., Pitart, C., del Pozo, J. L., Ramírez, P., Rascado, P., Reyes, S., Ruiz-Garbajosa, P., Suberviola, B., ...

- Zaragoza, R. (2023). Ten Issues to Update in Nosocomial or Hospital-Acquired Pneumonia: An Expert Review. *Journal of Clinical Medicine*, 12(20). <https://doi.org/10.3390/jcm12206526>
- Chen, C. H., Tu, C. Y., Chen, W. C., Kuo, L. K., Wang, Y. T., Fu, P. K., Ku, S. C., Fang, W. F., Chen, C. M., & Lai, C. C. (2021). Clinical efficacy of cefoperazone-sulbactam versus piperacillin-tazobactam in the treatment of hospital-acquired pneumonia and ventilator-associated pneumonia. *Infection and Drug Resistance*, 14, 2251-2258. <https://doi.org/10.2147/IDR.S313828>
- Chen, W., Chen, Y., Tang, Q., Kong, D., Xu, M., Yang, Y., Li, Q., & Yang, M. (2025). Analysis of risk-factors associated with hospital-acquired pneumonia in patients with alzheimer's disease based on gender differences. *BMC Geriatrics*, 25(1). <https://doi.org/10.1186/s12877-025-06276-y>
- Crémet, L., Gaborit, B., Bouras, M., Drumel, T., Guillotin, F., Poulain, C., Persyn, E., Lakhal, K., Rozec, B., Vibet, M. A., Roquilly, A., & Gibaud, S. (2020). Evaluation of the FilmArray® Pneumonia Plus Panel for Rapid Diagnosis of Hospital-Acquired Pneumonia in Intensive Care Unit Patients. *Frontiers in Microbiology*, 11. <https://doi.org/10.3389/fmicb.2020.02080>
- Dessajan, J., Thy, M., Doman, M., Stern, J., Gallet, A., Fouque, G., Chosidow, S., Ruckly, S., Gueye, S., Lamara, F., Dlela, M., Rego, H. Do, Ejzenberg, M., Haudebourg, L., Le Marec, J., Potier, C., Berti, V., Grall, N., Lo, S., ... Timsit, J. F. (2025). Assessing FilmArray Pneumonia+ panel dynamics during antibiotic treatment to predict clinical success in ICU patients with ventilated hospital-acquired pneumonia and ventilator-associated pneumonia: a multicenter prospective study. *Critical Care*, 29(1). <https://doi.org/10.1186/s13054-025-05503-7>
- Ehrenzeller, S., & Klompas, M. (2024). Association Between Daily Toothbrushing and Hospital-Acquired Pneumonia A Systematic Review and Meta-Analysis. *JAMA Internal Medicine*, 184(2), 131-142. <https://doi.org/10.1001/jamainternmed.2023.6638>
- Erich, B. J., Kilic, A., Palavecino, E., Williamson, J., Johnson, J., Ohl, C., Luther, V., & Beardsley, J. (2022). Evaluation of the Potential Impact of a Multiplex Rapid Diagnostic Panel in Critically Ill Patients With Hospital-Acquired Pneumonia. *Cureus*. <https://doi.org/10.7759/cureus.21716>
- Fally, M., Haseeb, F., Kouta, A., Hansel, J., Robey, R. C., Williams, T., Welte, T., Felton, T., & Mathioudakis, A. G. (2024). Unravelling the complexity of ventilator-associated pneumonia: a systematic methodological literature review of diagnostic criteria and definitions used in clinical research. *Critical Care*, 28(1). <https://doi.org/10.1186/s13054-024-04991-3>
- Fang, Z., Zhou, X., Liao, H., & Xu, H. (2023). A meta-analysis of *Legionella pneumophila* contamination in hospital water systems. *American Journal of Infection Control*, 51(11), 1250-1262. <https://doi.org/10.1016/j.ajic.2023.04.002>
- Gatti, M., Giannella, M., Rinaldi, M., Gaibani, P., Viale, P., & Pea, F. (2022). Pharmacokinetic/ Pharmacodynamic Analysis of Continuous-Infusion Fosfomycin in Combination with Extended-Infusion Cefiderocol or Continuous-Infusion Ceftazidime-Avibactam in a Case Series of Difficult-to-Treat Resistant *Pseudomonas aeruginosa* Bloodstream Infections and/or Hospital-Acquired Pneumonia. *Antibiotics*, 11(12). <https://doi.org/10.3390/antibiotics11121739>

- Ghadimi, M., Siemieniuk, R. A. C., Guyatt, G., Loeb, M., Hazzan, A. A., Aminaie, D., Gomaa, H., Wang, Y., Yao, L., Agarwal, A., Basmaji, J., Grant, A., Kim, W. S. H., Alvarado-Gamarra, G., Likhvantsev, V., Lima, J. P., Motaghi, S., Couban, R., Sadeghirad, B., & Brignardello-Petersen, R. (2024). Empiric antibiotic regimens in adults with non-ventilator-associated hospital-acquired pneumonia: a systematic review and network meta-analysis of randomized controlled trials. *Clinical Microbiology and Infection*, 30(11), 1351-1363. <https://doi.org/10.1016/j.cmi.2024.05.017>
- Girón, R. M., Ibáñez, A., Gómez-Punter, R. M., & Alarcón, T. (2022). New evidence in severe pneumonia: imipenem/cilastatin/relebactam. *Revista Espanola de Quimioterapia*, 35, 46-49. <https://doi.org/10.37201/req/s01.11.2022>
- Guillotin, F., Poulain, C., Gaborit, B., Bouras, M., Cinotti, R., Lakhal, K., Vourc'h, M., Rozec, B., Asehnoune, K., Vibet, M. A., Riche, V. P., Gibaud, S. A., Crémet, L., & Roquilly, A. (2022). Potential Impact of Rapid Multiplex PCR on Antimicrobial Therapy Guidance for Ventilated Hospital-Acquired Pneumonia in Critically Ill Patients, A Prospective Observational Clinical and Economic Study. *Frontiers in Cellular and Infection Microbiology*, 12. <https://doi.org/10.3389/fcimb.2022.804611>
- Guo, T., Dou, L., & Zhou, X. (2021). Risk factors of stroke complicated with hospital-acquired pneumonia: a systematic review and meta-analysis of cohort studies. *Annals of Palliative Medicine*, 10(12), 12381-12389. <https://doi.org/10.21037/apm-21-3278>
- Hasan Delina, S. Y. (2024). Quantitative Study of Antibiotic usage in Pneumonia patients: Systematic literature review, 4(1). <http://eduvest.greenvest.co.id>
- High, J., Enne, V. I., Barber, J. A., Brealey, D., Turner, D. A., Horne, R., Peters, M., Dhesi, Z., Wagner, A. P., Pandolfo, A. M., Stirling, S., Russell, C., O'Grady, J., Swart, A. M., Gant, V., Livermore, D. M., Shallcross, L., Cuesta, J., Singh, S., ... Klein, N. (2021). Inahale: the impact of using FilmArray Pneumonia Panel molecular diagnostics for hospital-acquired and ventilator-associated pneumonia on antimicrobial stewardship and patient outcomes in UK Critical Care—study protocol for a multicentre randomised controlled trial. *Trials*, 22(1). <https://doi.org/10.1186/s13063-021-05618-6>
- Huang, M., Wang, W., Li, W. L., Chen, Y. Q., Chen, X. T., Liu, Y., Li, Y., Ren, D. M., & Wang, F. (2025). Construction and evaluation of a nomogram model for predicting the risk of hospital-acquired pneumonia in elderly patients with acute ischemic stroke. *BMC Geriatrics*, 25(1). <https://doi.org/10.1186/s12877-025-05936-3>
- Kamel, N. A., Alshahrani, M. Y., Aboshanab, K. M., & El Borhamy, M. I. (2022). Evaluation of the BioFire FilmArray Pneumonia Panel Plus to the Conventional Diagnostic Methods in Determining the Microbiological Etiology of Hospital-Acquired Pneumonia. *Biology*, 11(3). <https://doi.org/10.3390/biology11030377>
- Kanj, S. S., Bassetti, M., Kiratisin, P., Rodrigues, C., Villegas, M. V., Yu, Y., & van Duin, D. (2022). Clinical data from studies involving novel antibiotics to treat multidrug-resistant Gram-negative bacterial infections. *International Journal of Antimicrobial Agents*, 60(3). <https://doi.org/10.1016/j.ijantimicag.2022.106633>

- Karunarathna, I., Gunasena, P., Aluthge, P., Perera, N., Gunathilake, S., De Alvis, K., Gunawardana, K., Rajapaksha, S., Warnakulasooriya, A., Athulgama, P., Dias, S., Ranwala, R., Bandara, S., Godage, S., Pn, R., Jayawardana, A., Vidanagama, U., Fernando, C., Ekanayake, U., & Hapuarachchi, T. (2025). Conclusion and Future Directions in Mechanical.
- Kim, B. G., Kang, D., Min, K. H., Cho, J., & Jeon, K. (2023). Comparison of Cefepime with Piperacillin/Tazobactam Treatment in Patients with Hospital-Acquired Pneumonia. *Antibiotics*, 12(6). <https://doi.org/10.3390/antibiotics12060984>
- Kozub, E., Gorzycki, E., Sidebottom, A., Castro-Pearson, S., & Bryant, R. (2025). Implementation of a structured oral hygiene program through nursing assistant education to address non-ventilator hospital-acquired pneumonia: A quasi-experimental study. *Journal of Nursing Scholarship*, 57(2), 204-215. <https://doi.org/10.1111/jnu.13018>
- León César, O. T. E. C. C. J. (2016). Características epidemiológicas de la neumonía intrahospitalaria en un servicio de medicina interna del hospital Guillermo Almenera Irigoyen de Lima, Perú.
- Li, J., Wei, F., Xiang, P., Tang, Z., Ding, L., Chen, L. F., Losada, M., Iamboliyska, Z., Sun, F., Zhu, M., Guo, X., Du, X., Chen, C., Bruno, C., Koseoglu, S., Young, K., Zhou, M., & Qu, J. (2025). A phase III, randomized, controlled noninferiority trial to study the efficacy and safety of imipenem/cilastatin/relebactam (IMI/REL) vs piperacillin/tazobactam (PIP/TAZ) in patients with hospital-acquired bacterial pneumonia (HABP) or ventilator-associated bacterial pneumonia (VABP). *International Journal of Infectious Diseases*, 153. <https://doi.org/10.1016/j.ijid.2024.107357>
- Lopez-De-Andrés, A., López-Herranz, M., Hernández-Barrera, V., De-Miguel-Diez, J., De-Miguel-Yanes, J. M., Carabantes-Alarcón, D., Albaladejo-Vicente, R., Villanueva-Orbaiz, R., & Jiménez-García, R. (2021). Sex differences in hospital-acquired pneumonia among patients with type 2 diabetes mellitus patients: Retrospective cohort study using hospital discharge data in Spain (2016-2019). *International Journal of Environmental Research and Public Health*, 18(23). <https://doi.org/10.3390/ijerph182312645>
- Lukasewicz Ferreira, S. A., Hubner Dalmora, C., Anziliero, F., de Souza Kuchenbecker, R., & Klarmann Ziegelmann, P. (2022). Factors predicting non-ventilated hospital-acquired pneumonia: systematic review and meta-analysis. *Journal of Hospital Infection*, 119, 64-76. <https://doi.org/10.1016/j.jhin.2021.09.024>
- Massart, N., Mansour, A., Ross, J. T., Piau, C., Verhoye, J. P., Tattevin, P., & Nessler, N. (2022). Mortality due to hospital-acquired infection after cardiac surgery. *Journal of Thoracic and Cardiovascular Surgery*, 163(6), 2131-2140.e3. <https://doi.org/10.1016/j.jtcvs.2020.08.094>
- Mazloomirad, F., Hasanzadeh, S., Sharifi, A., Nikbakht, G., Roustaei, N., & Khoramrooz, S. S. (2021). Identification and detection of pathogenic bacteria from patients with hospital-acquired pneumonia in southwestern Iran; evaluation of biofilm production and molecular typing of bacterial isolates. *BMC Pulmonary Medicine*, 21(1). <https://doi.org/10.1186/s12890-021-01773-3>
- Miron, M., Blaj, M., Ristescu, A. I., Iosep, G., Avădanei, A. N., Iosep, D. G., Crișan-Dabija, R.,

- Ciocan, A., Perțea, M., Manciu, C. D., Luca, Ștefana, Grigorescu, C., & Luca, M. C. (2024). Hospital-Acquired Pneumonia and Ventilator-Associated Pneumonia: A Literature Review. *Microorganisms*, 12(1). <https://doi.org/10.3390/microorganisms12010213>
- Munive, A. A., Ortiz Ruiz, G., Dueñas, C., & De La Asociación, C. (2013). Consenso colombiano de neumonía nosocomial 2013, 17(1). www.elsevier.es/infectio
- Naik, J., Dillon, R., Massello, M., Ralph, L., & Yang, Z. (2023). Cost-effectiveness of imipenem/cilastatin/relebactam for hospital-acquired and ventilator-associated bacterial pneumonia. *Journal of Comparative Effectiveness Research*, 12(3). <https://doi.org/10.2217/cer-2022-0113>
- Natarajan, K., Bahulikar, A., & Phalgune, D. S. (2025). Ventilator-associated Pneumonia: A Prospective Observational Study. *Journal of Association of Physicians of India*, 73(5), 21-24. <https://doi.org/10.59556/japi.73.0970>
- Odoyo, E., Matano, D., Tiria, F., Georges, M., Kyanya, C., Wahome, S., Mutai, W., & Musila, L. (2023). Environmental contamination across multiple hospital departments with multidrug-resistant bacteria pose an elevated risk of healthcare-associated infections in Kenyan hospitals. *Antimicrobial Resistance and Infection Control*, 12(1). <https://doi.org/10.1186/s13756-023-01227-x>
- Oznur, E., Guzeldag, S., & Cakir, N. (2021). Evaluating causative agents, mortality factors, and laboratory data of hospital-acquired pneumonia patients. *Revista Da Associacao Medica Brasileira*, 67(12), 1846-1851. <https://doi.org/10.1590/1806-9282.20210764>
- Pei, Y., Huang, Y., Pan, X., Yao, Z., Chen, C., Zhong, A., Xing, Y., Qian, B., Minhua, S., & Zhou, T. (2023). Nomogram for predicting 90-day mortality in patients with *Acinetobacter baumannii*-caused hospital-acquired and ventilator-associated pneumonia in the respiratory intensive care unit. *Journal of International Medical Research*, 51(3). <https://doi.org/10.1177/03000605231161481>
- Plaisance, C. J., Borne, G. E., Daniel, C. P., Wagner, M. J., Shelvan, A., Mathew, J., Ahmadzadeh, S., Paladini, A., Varrassi, G., Shekoohi, S., & Kaye, A. D. (2024). Cefiderocol (Fetroja) as a Treatment for Hospital-Acquired Pneumonia. *Cureus*, 16(1) <https://doi.org/10.7759/cureus.52230>
- Poovieng, J., Sakboonyarat, B., & Nasomsong, W. (2022). Bacterial etiology and mortality rate in community-acquired pneumonia, healthcare-associated pneumonia and hospital-acquired pneumonia in Thai university hospital. *Scientific Reports*, 12(1). <https://doi.org/10.1038/s41598-022-12904-z>
- Quarton, S., Livesey, A., Pittaway, H., Adiga, A., Grudzinska, F., McNally, A., Dosanjh, D., Sapey, E., & Parekh, D. (2024). Clinical challenge of diagnosing non-ventilator hospital-acquired pneumonia and identifying causative pathogens: a narrative review. *Journal of Hospital Infection*, 149, 189-200. <https://doi.org/10.1016/j.jhin.2024.02.029>
- Ramirez, G., Campanero, M. A., Zaldua, A. M., & Jauregizar, N. (2024). Problems Related to Endotracheal Intubation as an Input for the Design of a New Endotracheal Tube. *Medical*

- Devices: Evidence and Research, 17, 349-367. <https://doi.org/10.2147/MDER.S475964>
- Rashid, M. H., Bukhari, S. N. Y., Mousa, A., Aziz, A. A., & Hakobyan, K. (2023). Cefiderocol as a Treatment Option for *Stenotrophomonas maltophilia* Causing Hospital-Acquired/Ventilator-Associated Pneumonia. *Cureus*, 15(5). <https://doi.org/10.7759/cureus.38613>
- Ren, Y., Liang, J., Li, X., Deng, Y., Cheng, S., Wu, Q., Song, W., He, Y., Zhu, J., Zhang, X., Zhou, H., & Yin, J. (2023). Association between oral microbial dysbiosis and poor functional outcomes in stroke-associated pneumonia patients. *BMC Microbiology*, 23(1). <https://doi.org/10.1186/s12866-023-03057-8>
- Solórzano-Martínez, I., Anlehu-Tello, A., Blanco de la Vega-Pérez, R., & De los Santos-Hernández, F. E. (2020). In-hospital pneumonia associated with mechanical ventilation in a hospital in the state of Tabasco, Mexico. *Actualidad Médica*, 105(105(810)), 85-89. <https://doi.org/10.15568/am.2020.810.or01>
- Tehan, P. E., Browne, K., Matterson, G., Cheng, A. C., Dawson, S., Graves, N., Johnson, D., Kiernan, M., Madhuvu, A., Marshall, C., McDonagh, J., Northcote, M., O'Connor, J., Orr, L., Rawson, H., Russo, P., Sim, J., Stewardson, A. J., Wallace, J., ... Mitchell, B. G. (2024). Oral care practices and hospital-acquired pneumonia prevention: A national survey of Australian nurses. *Infection, Disease and Health*, 29(4), 212-217. <https://doi.org/10.1016/j.idh.2024.04.006>
- Titov, I., Wunderink, R. G., Roquilly, A., Gonzalez, D. R., David-Wang, A., Boucher, H. W., Kaye, K. S., Losada, M. C., Du, J., Tipping, R., Rizk, M. L., Patel, M., Brown, M. L., Young, K., Kartsonis, N. A., Butters, J. R., Paschke, A., & Chen, L. F. (2021). A Randomized, Double-blind, Multicenter Trial Comparing Efficacy and Safety of Imipenem/Cilastatin/Relebactam Versus Piperacillin/Tazobactam in Adults With Hospital-acquired or Ventilator-associated Bacterial Pneumonia (RESTORE-IMI 2 Study). *Clinical Infectious Diseases*, 73(11), E4539-E4548. <https://doi.org/10.1093/cid/ciaa803>
- Ukai, T., Maruyama, T., Tomioka, S., Fukui, T., Matsuda, S., Fushimi, K., & Iso, H. (2023). Predictors of hospital mortality and multidrug-resistant pathogens in hospitalized pneumonia patients residing in the community: Predictors of mortality and MDR pathogens. *Heliyon*, 9(12). <https://doi.org/10.1016/j.heliyon.2023.e22303>
- Wang, Z., Chang, B., Zhang, Y., Chen, J., Xie, F., Xiang, Y., Liu, T., & Li, Y. (2022). Clinical value of serum sTREM-1 and HBP levels in combination with traditional inflammatory markers in diagnosing hospital-acquired pneumonia in elderly. *BMC Infectious Diseases*, 22(1). <https://doi.org/10.1186/s12879-022-07758-9>
- Wattoo, M. A., Tabassum, M., Bhutta, K. R., Rafi, Z., Kaneez, M., Razzaq, M. T., Rizwan, R., Sarwar, Z., Sajid, M. U., & Bhutta, F. R. (2021). Clinical and Microbiological Analysis of Hospital-Acquired Pneumonia Among Patients With Ischemic Stroke: A Retrospective Outlook. *Cureus*, 13(5). <https://doi.org/10.7759/cureus.15214>
- Xu, Y., Xue, J., Deng, Y., Tu, L., Ding, Y., Zhang, Y., Yuan, X., Xu, K., Guo, L., & Gao, N. (2025). Advances in Machine Learning for Mechanically Ventilated Patients. *International Journal of General Medicine*, 18(1), 3301-3311. <https://doi.org/10.2147/ijgm.s515170>

- Yakoub, M., Elkhwsky, F., El Tayar, A., & El Sayed, I. (2023). Hospital-acquired pneumonia pattern in the intensive care units of a governmental hospital: A prospective longitudinal study. *Annals of African Medicine*, 22(1), 94-100. https://doi.org/10.4103/aam.aam_178_21
- Yao, W., Sun, X., Tang, W., Wang, W., Lv, Q., & Ding, W. (2024). Risk factors for hospital-acquired pneumonia in hip fracture patients: a systematic review and meta-analysis. *BMC Musculoskeletal Disorders*, 25(1). <https://doi.org/10.1186/s12891-023-07123-0>
- Yu, W., Dan, L., Cai, J., Wang, Y., Wang, Q., Zhang, Y., & Wang, X. (2024). Incidence of post-extubation dysphagia among critical care patients undergoing orotracheal intubation: a systematic review and meta-analysis. *European Journal of Medical Research*, 29(1), 444. <https://doi.org/10.1186/s40001-024-02024-x>
- Zaragoza, R., Vidal-Cortés, P., Aguilar, G., Borges, M., Díaz, E., Ferrer, R., Maseda, E., Nieto, M., Nuvials, F. X., Ramírez, P., Rodríguez, A., Soriano, C., Veganzones, J., & Martín-Loeches, I. (2020). Update of the treatment of nosocomial pneumonia in the ICU. *Critical Care*, 24(1). <https://doi.org/10.1186/s13054-020-03091-2>
- Zha, L., Li, X., Ren, Z., Zhang, D., Zou, Y., Pan, L., Li, S., Chen, S., & Tefsen, B. (2022). Pragmatic Comparison of Piperacillin/Tazobactam versus Carbapenems in Treating Patients with Nosocomial Pneumonia Caused by Extended-Spectrum B-Lactamase-Producing *Klebsiella pneumoniae*. *Antibiotics*, 11(10). <https://doi.org/10.3390/antibiotics11101384>
- Zilberberg, M. D., Nathanson, B. H., Puzniak, L. A., & Shorr, A. F. (2022). Descriptive Epidemiology and Outcomes of Nonventilated Hospital-Acquired, Ventilated Hospital-Acquired, and Ventilator-Associated Bacterial Pneumonia in the United States, 2012-2019. *Critical Care Medicine*, 50(3), 460-468. <https://doi.org/10.1097/CCM.0000000000005298>