MEDICAL SCIENCE

To Cite:
Al-Naam NA, Al-Anazi NM, Al-Aliani AN, Abahoussin OK, Majrashi AAM, Alqahtani JS, Alaqeily AH, Almohaimid NA, Alanezi MS. *Medical Science* 2023; 27: e370ms3244
doi: https://doi.org/10.54905/disssi.v27i140.e370ms3244

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Peer-Review History
Received: 03 August 2023
Reviewed & Revised: 07/August/2023 to 21/October/2023
Accepted: 25 October 2023
Published: 31 October 2023

Peer-review Method
External peer-review was done through double-blind method.

Medical Science
pISSN 2321–7359; eISSN 2321–7367

Ventilator associated pneumonia in ICU patients: Systematic review

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ABSTRACT

Pneumonia contracted in an intensive care unit by patients invasively intubated for mechanical ventilation is known as ventilator-associated pneumonia. Ventilator-associated pneumonia patients have a higher mortality risk, a greater cost burden, and a longer hospital stay. In the time period from 2010 to 2022 we tried to collect all articles according to our inclusion criteria published in Pubmed, Google scholar and PLOS ONE, then review was done according to PRISMA standard 2020, we reviewed the abstract and full text of selected articles, then we extracted information regarding studies purposes and main findings. Ten articles were reviewed we found that ventilator-associated pneumonia incidence is higher in men than women with mean of male percentage 62.9, mean of overall sample size was 9470.77 and the median was 422. The means of ICU mortality, ventilator associated pneumonia incidence length of stay in the ICU in days were 21.34, 19.12, and 8.82 respectively. This research's results can help establish infection control and prevention measures that will lessen ventilator-associated pneumonia impact. To stop this preventable threat from spreading at dangerous rate, control and preventative measures, such as interventional research and educational programs on staff training, hand sanitization, and the proper use of ventilator bundle approaches, are urgently needed.

Keywords: Ventilator associated pneumonia, mechanical ventilation, intensive care unit

1. INTRODUCTION

When pneumonia develops more than 48 to 72 hours after endotracheal intubation and is not present at admission time, it is known as ventilator-associated pneumonia (VAP) or intubation-associated pneumonia (Papazian et al., 2020). Patients with VAP experience new or advancing infiltrates, fever, altered white blood cell counts (WBCs), modifications in the properties of sputum, and the identification of a causal agent (Metersky and Kalil, 2018).

DISCOVERY SCIENTIFIC SOCIETY

Invasively mechanically ventilated patients will most likely get ICU VAP (Papazian et al., 2020). VAP patients have a 13.5% mortality rate. As a result, both the length of hospital stays and the associated cost burden rise. Even though delayed antimicrobial medication administration has been linked to higher mortality Mumtaz et al., (2023), early detection of VAP is critical. It's critical to strike a balance between the hazards of antibiotic misuse, such as antibiotic resistance and co-infections, and the requirement for timely antibiotic delivery, particularly in the ICU.

VAP is hard to recognise, making it tough to find the proper balance. Up to two-thirds of patients who are given a VAP diagnosis do not always have the condition (Mumtaz et al., 2023). The incidence and effects of VAP vary greatly depending on the language used. Improved approaches for determining the usage of empirical antibiotics and diagnosing VAP are urgently needed (Dominedò et al., 2020). Clinicians frequently rely on diagnostic, radiographic, and laboratory signs to identify the existence of VAP and initiate empiric antibiotics. Symptoms of VAP includes; fever, the generation of sputum, hypoxemia, a newly or recently established infiltrate on chest radiography, an elevated WBCs, and abnormal cultures from ETA or bronchoscopic sample procedures (bronchoalveolar lavage and protected specimen brush).

The “clinical lung infection score” (CPIS), the most popular of them, has been incorporated into clinical models. Although these signs and tests are frequently utilised, it is unknown how effective they are at identifying VAP (Sterne et al., 2016). Estimating the incidence, death rate, and etiological causes of VAP is the major goal of our review. In order to plan infection control and other prevention strategies to control this preventable disease and lower the mortality associated with it for the future, patients, clinicians, and policy makers would benefit from having access to this reliable and updated information. It would also help them assess the significance of the situation.

2. METHOD

We constructed this systematic review in compliance PRISMA “Preferred Reporting Items for Systematic Reviews” (Page et al., 2021). Guidelines for Diagnostics Accuracy Level, and other reviews of Diagnostics Give Accurate information criteria.

Information sources and search strategy

To find all the peer-reviewed research publications published between the years of 2010 and 2022, four authors separately carried out a thorough literature search in three electronic databases: Google Scholar databases, PLOS ONE, and PubMed. The accompanying file for the search strategy contains a detailed description of the entire search strategy for PubMed and PLOS ONE. We used pertinent MeSH Terms from PubMed, PLOS ONE, and Google Scholar to search every database. MeSH phrases were used to search for "Ventilator-associated Pneumonia" and "Healthcare-Associated Pneumonia". For further pertinent papers, every reference to the research that met evaluation criteria was carefully searched.

Study inclusion and exclusion criteria

The inclusion criteria included information on the prevalence, incidence, or incidence rate of VAP among adults reported as episodes per 1000 ventilator days in randomised controlled trials and cohort studies that were published in English. Exclusion standards of our review, we omitted review articles, study protocols, case series/case reports, symposium/conference proceedings, commentaries/editorials/letters, views/opinions, papers not in English, and articles whose full texts were not accessible.

Analysis and review

The abstracts were reviewed, the full texts of the included articles were revised, and the pertinent data were then extracted. The information that was extracted includes the study's design, patient characteristics, the study's purpose, and key findings, as well as the author's name and the year it was published. Before being imported into an already created table, the retrieved values were modified in an Excel spreadsheet.

3. RESULTS

Studying choice, a comprehensive search of the databases yielded a total of 1891 articles. There were still 256 items to be processed after the initial scanning. 205 of those papers were excluded after the title and abstract screening because they did not adhere to the inclusion criteria. The remaining articles full-text were read. 41 of the 51 full-text entries were disregarded because the relevant findings could not be located. Finally, the review contained 10 papers (Figure 1). Ten studies total, involving both adult and paediatric admitted to ICU in diverse hospital settings, were examined. In studies, the diagnostic standard for VAP expressed in

each 1000 ventilator days was provided by the US Centres for Disease Control and Prevention. Countries in which studies were conducted includes the China, Nigeria, France, Bosnia and Herzegovina, Turkey, United States, Portugal, and Lebanon.

Table 1 gives a description of each study individually, while Table 2, includes detailed descriptive statistics, it is shown that men incidence (62.9) is larger than women incidence (37.1), incidence for ventilator-associated pneumonia is (19.12%) and the mortality rate in ICU, is 21.3%. Table 2 display descriptive statistical data of reviewed papers. Some of the reviews' articles included information on hospitalized patients' mortality rates. A mortality rate of 6.3% to 66.9% was recorded. According to research, Turkey Mangram et al., (2015) was the country with the greatest mortality rate. Studies conducted in China, Lebanon, Bosnia, and Herzegovina did not report mortality rates.

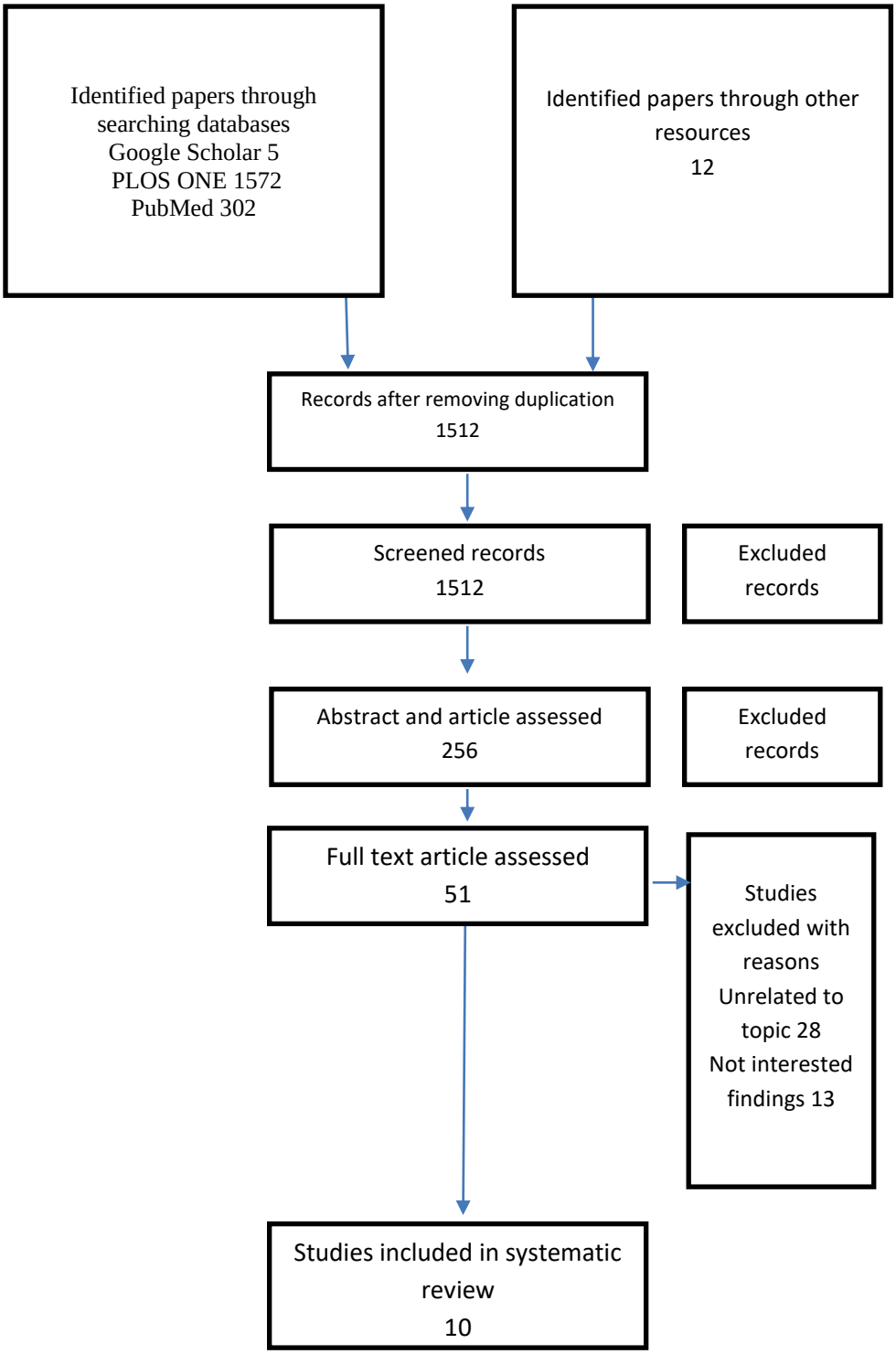

Figure 1 Selection process (PRISMA consort chart)

Table 1 Characteristics of the study selected

Author / publication year	Study design	Study population characteristics	Study objective	Main findings
Bonell et al., 2019	Analytical study	Not applicable	In order to determine the incidence, prevalence, and aetiology of VAP, the study rigorously examine all academic articles published on Ovid Medline, Embase Classic, and Embase between 1 January 1990 and 17 August 2017.	Antibiotic resistance is prevalent, and VAP continues to be a common cause of HAI, particularly in low- and middle-income countries.
He Q et al., 2021	Prospective study	Between April 1, 2015, and December 31, 2018, patients who were hospitalised to ICUs and received MV were included.	Based on a prospectively kept registry, this study seeks to evaluate the epidemiology and clinical consequences of VAEs.	VAE was widespread in ICU patients who had four or more days on a ventilator. Poor clinical outcomes, including lengthier ICU and hospital stays and a higher risk of mortality, were strongly linked with all VAE categories.
Iwuafor et al., 2016	Retrospective cohort study	71 patients were enrolled, incidence rate is 79/1000 patient-days in the ICU (45% healthcare linked infection rate).	In the intensive care unit, this study identified the prevalence, risk factors, clinical outcome, and microbiological profile of hospital-acquired infections.	Even after accounting for APACHE II score, healthcare linked infections remain a substantial risk factor for ICU mortality and morbidity.
Philippart et al., 2015	Retrospective cohort study	11% had IAI and 88% had other infections out of 2623 database patients who met the inclusion criteria.	The aim of this study is to look into the potential impact of IAI at the time of ICU admission on the development of VAP.	VAP developed less frequently and later in patients with severe sepsis and/or septic shock in the group with IAIs compared to the group with other sites infections.
Mangram et al., 2015	Prospective study	Of the 1,044 ventilated trauma patients, 95 suffered from pneumonia were included.	Trauma-related factors role in the development of VAP.	It is necessary to alter the definition of VAP used by the CDC to account for the role trauma factors play in the development of trauma-associated pneumonia.
Costa et al., 2019	Retrospective cohort study	60 individuals with Pneumonia. An intensive care unit acquired pneumonia affected 58%, for a total of 6.9 / 1000 patients who required intubation.	This study sought to assess the demographics, incidence, risk factors, bacterial infections responsible for the illness, and prognosis of all cases of hospital-acquired pneumonia in hospital.	The most common cause of nosocomial pneumonia was S. aureus.
Vacheron et al., 2022	Prospective study	Admitted COVID 19 patients matched on the certain criteria including; "age, sex, center of inclusion, presence of antimicrobial therapy at admission, patient provenance, time from ICU admission	Incidence or etiological factors for ventilator-acquired pneumonia in coronavirus patients in 2019	Compared to the general ICU population, patients with coronavirus illness in 2019 had a greater prevalence of ventilator-associated pneumonia.

		to mechanical ventilation, and Simplified Acute Physiology Score II at admission" in the period of 2016 to 2019.		
Hsieh et al., 2010	Retrospective cohort study	The study enrolled 397 patients	This study's goal was to investigate the prevalence of and risk factors for VAP in PICU.	In pediatric patients, weekly ventilator circuit change did not result in higher rates of VAP.
Decelle et al., 2013	Prospective study	Over the course of a year, all intubated adults who were later hospitalized to the ICU were counted, which include 75 patients.	The study's objective was to assess the prevalence and risk factors of VAP among intubated patients receiving care in the emergency room.	Clinical macro aspiration was a clinical feature present at the time of intubation, out-of-hospital intubation was the rationale for it. The mortality rate for patients with VAP was 17% and was not appreciably higher.
De-Miguel et al., 2017	Prospective study	study found 9336 admissions involving patients who had VAP.	This study's objective was to investigate trends in VAP incidence and outcomes among hospitalized patients in Spain from 2010 to 2014.	"Male sex, older age, higher CCI, vein or artery blockage, lung disease, cancer, had surgery, emergency department admission, and readmission" were all were linked to greater IHM.

Table 2 Descriptive statistics

	Males percentage	Females percentage	Sample size (*number*)	Mean of the age distribution (years)	Stay length of in the ICU in days (mean)	VAP Incidence	ICU mortality
Mean	62.9	37.1	9470.77	49.5	8.82	19.12	21.34
Median	64.4	35.6	422.00	51.5	8.6	16.82	19.45

4. DISCUSSION

In our review, we analyze studies on the prevalence of VAP in the populations of China, Nigeria, France, Bosnia and Herzegovina, Turkey, United States, Portugal, and Lebanon. In these countries, we discovered a wide range of VAP load and significant variation in the VAP rate, ranging from 7.0 to 43.0 per thousand ventilator days, indicating that the majority of studies had unsettling VAP circumstances. Gram-negative organisms were the primary source of mortality rates reported by the majority of the papers examined for this analysis, followed by gram-positive bacteria. The greater VAP rate in those nations may be due to economic disparities, which may then result in a lack of development and accessibility to healthcare facilities in some regions. Another likely explanation for the wide difference in the VAP rate is variations in the research environment, such as whether it was a paediatric or adult intensive care unit or a surgical or medical ICU.

Since there isn't a single, globally accepted definition for VAP, the criteria may also play a role in why VAP is occasionally over or under reported. A 2016 study in Qatar found that VAP was more common in male patients, younger patients (under 60), and admissions to trauma ICU. Hypertension and poly-trauma were the two most prevalent comorbidities (Ali et al., 2016). Staff practises that do not adhere to infection prevention recommendations could result in a variation in the VAP rate, with a higher rate in places where personnel is not fully adhering to the regulations, whether it be the prehospital emergency team or the medical staff working on hospital and ICU grounds (Mangram et al., 2015). VAP incidence was shown to be lower in good income nations (Bonell et al., 2019). Studies from the Middle East and Japan ranged from 8 to 12.6 per thousand ventilator days globally (Ali et al., 2016).

The papers in our review produce a variety of findings. While some research show rates similar to those of the studies mentioned above, other studies show a variablely greater incidence of VAP, increasing the VAP burden. The death rate for hospital-acquired pneumonia was reported to be greater in one of our studies. if HAP was the primary reason for admission the mortality rate will be high as opposed to patients who were admitted to the ICU for another reason (Costa et al., 2019). This might be because ICU patients receive more careful surveillance than patients in other wards in general, thus any deterioration could be quickly

identified and addressed by the ICU healthcare professionals before the patients deteriorate. Patients who acquire pneumonia somewhere else and seek medical assistance after symptoms have gotten bad enough for them to be hospitalized to the ICU might not experience this.

5. CONCLUSION

We found that the usual clinical indicators for the diagnosis of VAP, include; purulent discharges, fever, chest radiograph, leukocytosis, CPIS and cultures from three different sample techniques. Relying solely on the presence of any one of these symptoms could result in inaccurate diagnoses and likely unnecessary antibiotic usage. These results highlight the challenge of diagnosing VAP and the need for new tools to help physicians decide whether to start and stop empiric antibiotics for possible VAP.

Author's contribution

Nawaf Abdulkarim Alnaam: Participated in all research steps starting from the idea to the submission; Nawaf Mohammed Al-Anazi, Ali Nasser Al-Aliani, Othman Khalid Abahoussin: Participated in writing discussion and collecting literature; Ahmed Ali Mohammed Majrashi, Jalal Saeed Alqahtani, Ahmed Hamad Alaqeily, Naif Ahmed Almohaimid, Mohammed Shaim Alanezi: Participated in writing results method and introduction.

Abbreviations list

VAP: Ventilator-associated pneumonia
HAI: Hospital-acquired infection
ICU: Intensive care unit
MV: Mechanical ventilation
VAE: Ventilator-associated event
WBC: White blood cells
CDC: Center of disease control and prevention
APACHE: Acute physiology and chronic health evaluation
IAI: Intra-abdominal infection
PICU: Pediatric intensive care unit
IHM: In hospital mortality rate
CPIS: The clinical lung infection score.
ETA: Endotracheal Aspirate
HAP: Hospital-acquired pneumonia

Ethical approval

Not applicable

Funding

This study has not received any external funding.

Conflict of interest

The authors declare that there is no conflict of interests.

Data and materials availability

All data sets collected during this study are available upon reasonable request from the corresponding author.

REFERENCES AND NOTES

1. Ali HS, Khan FY, George S, Shaikh N, Al-Ajmi J. Epidemiology and Outcome of Ventilator-Associated Pneumonia in a Heterogeneous ICU Population in Qatar. Biomed Res Int 2016; 2016:8231787. doi: 10.1155/2016/8231787
2. Bonell A, Azarrafiy R, Huong VTL, Viet TL, Phu VD, Dat VQ, Wertheim H, van-Doorn HR, Lewycka S, Nadjm B. A

Systematic Review and Meta-analysis of Ventilator-associated Pneumonia in Adults in Asia: An Analysis of National Income Level on Incidence and Etiology. Clin Infect Dis 2019; 68(3):511-518. doi: 10.1093/cid/ciy543

3. Costa RD, Baptista JP, Freitas R, Martins PJ. Hospital-Acquired Pneumonia in a Multipurpose Intensive Care Unit: One-Year Prospective Study. Acta Med Port 2019; 32(12):746-753. doi: 10.20344/amp.11607
4. De-Miguel-Díez J, López-de-Andrés A, Hernández-Barrera V. Decreasing incidence and mortality among hospitalized patients suffering a ventilator-associated pneumonia: Analysis of the Spanish national hospital discharge database from 2010 to 2014. Medicine (Baltimore) 2017; 96(30):e7625. doi: 10.1097/MD.0000000000007625
5. Decelle L, Thys F, Zech F, Verschuren F. Ventilation-associated pneumonia after intubation in the prehospital or the emergency unit. Eur J Emerg Med 2013; 20(1):61-63. doi: 10.1097/MEJ.0b013e3283501677
6. Dominedò C, Ceccato A, Torres A. Ventilator-associated pneumonia: new principles guiding empiric antibiotic therapy. Curr Opin Infect Dis 2020; 33(2):182-188. doi: 10.1097/QCO.0000000000000640.
7. He Q, Wang W, Zhu S. The epidemiology and clinical outcomes of ventilator-associated events among 20,769 mechanically ventilated patients at intensive care units: an observational study. Crit Care 2021; 25(1):44. doi: 10.1186/s13054-021-03484-x
8. Hsieh TC, Hsia SH, Wu CT, Lin TY, Chang CC, Wong KS. Frequency of ventilator-associated pneumonia with 3-day versus 7-day ventilator circuit changes. Pediatr Neonatol 2010; 51(1):37-43. doi: 10.1016/S1875-9572(10)60008-3
9. Iwuafor AA, Ogunsola FT, Oladele RO, Oduyebo OO, Desalu I, Egwuatu CC, Nnachi AU, Akujobi CN, Ita IO, Ogban GI. Incidence, Clinical Outcome and Risk Factors of Intensive Care Unit Infections in the Lagos University Teaching Hospital (LUTH), Lagos, Nigeria. PLoS One 2016; 11(10):e0165242. doi: 10.1371/journal.pone.0165242
10. Mangram AJ, Sohn J, Zhou N. Trauma-associated pneumonia: time to redefine ventilator-associated pneumonia in trauma patients. Am J Surg 2015; 210(6):1056-1062. doi: 10.1016/j.amjsurg.2015.06.029
11. Metersky ML, Kalil AC. Management of Ventilator-Associated Pneumonia: Guidelines. Clin Chest Med 2018; 39(4):797-808. doi: 10.1016/j.ccm.2018.08.002
12. Mumtaz H, Saqib M, Khan W, Ismail SM, Sohail H, Muneeb M, Sheikh SS. Ventilator associated pneumonia in intensive care unit patients: a systematic review. Ann Med Surg (Lond) 2023; 85(6):2932-2939. doi: 10.1097/MS9.0000000000000836
13. Page MJ, McKenzie JE, Bossuyt PM. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. BMJ 2021; 372:n71. doi: 10.1136/bmj.n71
14. Papazian L, Klompas M, Luyt CE. Ventilator-associated pneumonia in adults: a narrative review. Intensive Care Med 2020; 46(5):888-906. doi: 10.1007/s00134-020-05980-0
15. Philippart F, Bouroche G, Timsit JF, Garrouste-Orgeas M, Azoulay E, Darmon M, Adrie C, Allaouchiche B, Ara-Somohano C, Ruckly S, Dumenil AS, Souweine B, Goldgran-Toledano D, Bouadma L, Misset B; Outcomerea study group. Decreased Risk of Ventilator-Associated Pneumonia in Sepsis Due to Intra-Abdominal Infection. PLoS One 2015; 10(9):e0137262. doi: 10.1371/journal.pone.0137262
16. Sterne JA, Hernán MA, Reeves BC, Savović J, Berkman ND, Viswanathan M, Henry D, Altman DG, Ansari MT, Boutron I, Carpenter JR, Chan AW, Churchill R, Deeks JJ, Hróbjartsson A, Kirkham J, Jüni P, Loke YK, Pigott TD, Ramsay CR, Regidor D, Rothstein HR, Sandhu L, Santaguida PL, Schünemann HJ, Shea B, Shrier I, Tugwell P, Turner L, Valentine JC, Waddington H, Waters E, Wells GA, Whiting PF, Higgins JP. ROBINS-I: a tool for assessing risk of bias in non-randomised studies of interventions. BMJ 2016; 355:i4919. doi: 10.1136/bmj.i4919
17. Vacheron CH, Lepape A, Savey A, Machut A, Timsit JF, Vanhems P, Le QV, Egbeola J, Martin M, Maxime V, Pugliesi PS, Maucort-Boulch D, Friggeri A, REA-REZO Study Group. Increased Incidence of Ventilator-Acquired Pneumonia in Coronavirus Disease 2019 Patients: A Multicentric Cohort Study. Crit Care Med 2022; 50(3):449–459. doi: 10.1097/CCM.0000000000005297